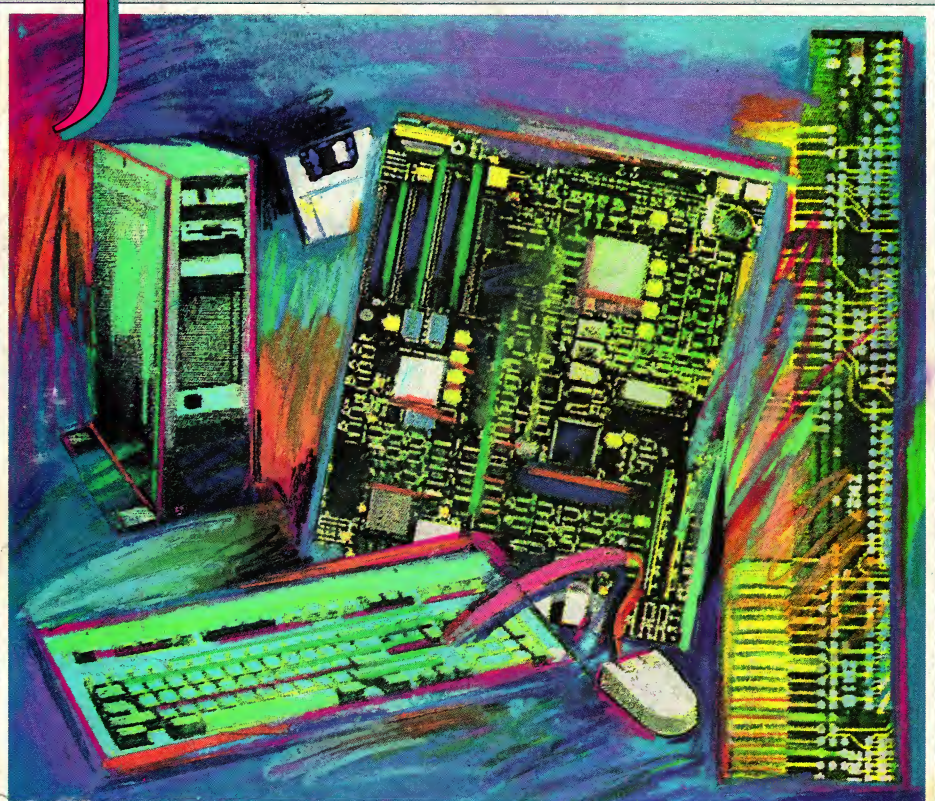
AUGUST 1987 VOL. 5 NO. 8 $3.95

FOR THE SYSTEMS PROFESSIONAL

PC TECH JOURNAL®



PORTRAITS OF THE PERSONAL SYSTEM/2

What IBM Did Right/Wrong

Models 30, 50, 60, 80 Reviewed

Twilight of DOS · Evolving Graphics

Disk Caching and Performance

LAN, 3270 Communications Developments

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Sieve benchmark

	Turbo C	Microsoft® C
Compile time	*2.4*	13.51
Compile and link time	*4.1*	18.13
Execution time	*3.95*	5.93
Object code size	*239*	249
Execution size	*5748*	7136
Price	*$99.95*	$450.00

Benchmark run on an IBM PS/2 Model 60 using Turbo C version 1.0 and the Turbo Linker version 1.0; Microsoft C version 4.0 and the MS overlay linker version 3.51.

Technical Specifications

- ☑ Compiler: One-pass optimizing compiler generating linkable object modules. Included is Borland's high-performance Turbo Linker.™ The object module is compatible with the PC-DOS linker. Supports tiny, small, compact, medium, large, and huge memory model libraries. Can mix models with near and far pointers. Includes floating point emulator (utilizes 8087/80287 if installed).
- ☑ Interactive Editor: The system includes a powerful, interactive full-screen text editor. If the compiler detects an error, the editor automatically positions the cursor appropriately in the source code.
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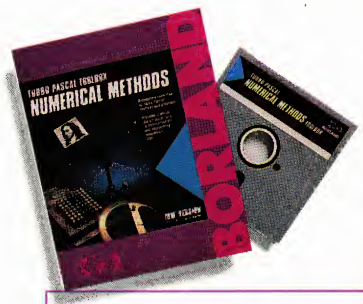
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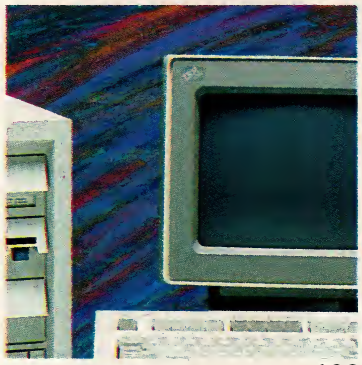
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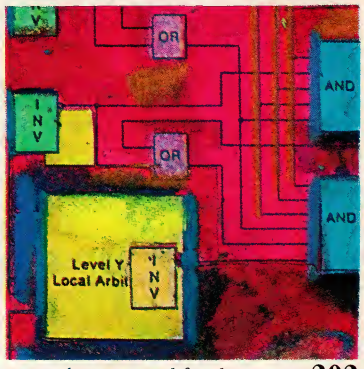
AUGUST 1987 VOLUME 5, NUMBER 8



LANs: Toward OS/2 **58**



Model 80: Performance, Potential **138**



An Architecture Redefined **202**

PORTRAITS OF THE PERSONAL SYSTEM/2

WHAT IBM DID RIGHT AND WRONG, PART/2 / WILL FASTIE
This dedicated PS/2 issue begins with overview and opinion: a seasoned systems professional scrutinizes the PS/2's key elements. 46

AN ARCHITECTURE REDEFINED / DAVID METHVIN
IBM cleans the slate with the Micro Channel Architecture. Radical in design, it preserves a high degree of software compatibility. 58

VGA: EVOLUTIONARY HALF-STEP / JOHN T. COCKERHAM
The Video Graphics Array, the graphics subsystem in Models 50, 60, and 80, will disappoint those hoping for a dramatic advancement. 74

MODEL 30: APART FROM THE FAMILY / TED MIRECKI
Lacking the Micro Channel and the VGA, the 8086-based Model 30 is a distant cousin to the other members of the new family. 92

MODELS 50 AND 60: NEW-GENERATION ATs / JIM SHIELDS
Models 50 and 60 share AT proficiency and improve on it in almost every way. They offer users a choice of performance and capacity. 110

MODEL 80: PERFORMANCE AND POTENTIAL / STEVEN ARMBRUST and CAROLINE HALLIDAY
The 80386-based Model 80 offers good performance now and stands poised for the advent of IBM's expected Operating System/2. 138

PS/2: THE MARKET CONTEXT / MARJORY SPRAYCAR
Considering a PS/2 purchase requires side-by-side comparisons with the competition—both in and out of the IBM product line. 156

THE CACHE FACTOR / MAXINE FONTANA
With and without caching software, PS/2 machines are evaluated to gain a first look at IBM's PS/2 performance strategy. 168

TWILIGHT OF DOS / JULIE ANDERSON
While not the long-awaited "new-and-improved" operating system, DOS 3.3 offers some worthwhile features—if used carefully. 180

EMERGING 3270 COHERENCE / MARY DEWOLF
Newly announced 3270 hardware and software signal IBM's intention to create a coherent line of micro-mainframe products. 194

LANs: TOWARD OS/2 / DAVID METHVIN
LAN products play an important role in the PS/2 family and provide an intriguing glimpse into future communications possibilities. 202

9 DIRECTIONS
Fragmenting the PC Market

15 LETTERS

30 TECH RELEASES

43 TECH NOTEBOOK
Which Math Coprocessor?

211 PRODUCT WATCH
Super PC-Kwik
Power Meter
Periscope 3.0
FastTrax

219 EXPERT CONSULTANT: *COMPUTER LAW*
Regional Copyright Law

228 TECH MART

234 TECH MARKETPLACE

244 CALENDAR

245 READER SERVICE CARD

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PC Tech Journal (ISSN 0738-0194) is published by Ziff-Davis Publishing Co., a division of Ziff Communications Co., One Park Ave., New York, NY 10016. Published monthly except semi-monthly in December. Subscription rate is $34.97 for one year (13 issues). Additional postage for Canada and Foreign is $.60/copy or $8.00/year. Second-class postage paid at New York, NY, and at additional mailing offices. POSTMASTER: Send address changes to PC Tech Journal, P.O. Box 2968, Boulder, CO 80321.

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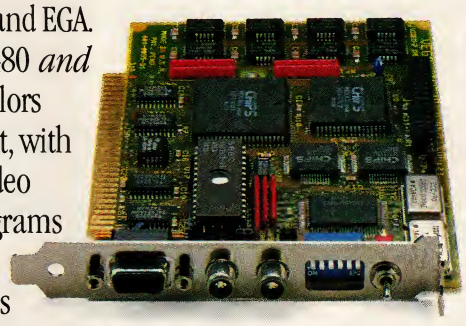
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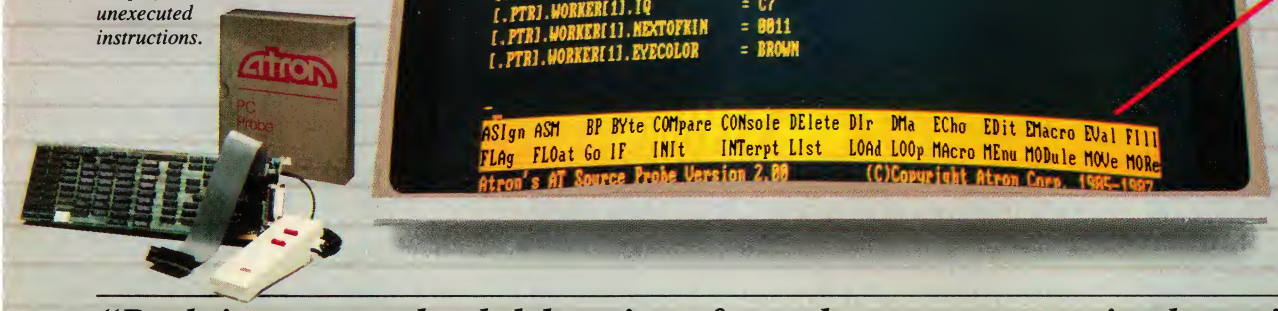
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Fragmenting the PC Market

Does the PS/2 family create a new standard, or does it simply add to the confusion?

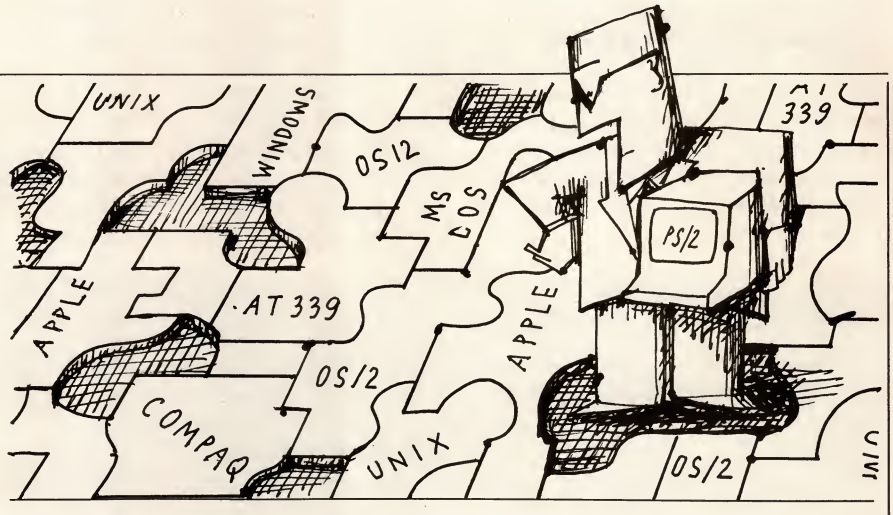


ILLUSTRATION • MACIEK ALBRECHT

COMDEX/Spring was well-timed this year in relation to the April 2 announcement of the IBM Personal System/2 family. Everyone had two months in which to ponder the significance of IBM's new product line and its software to come. I fully expected to hear an overdose of opinion about PS/2 and, particularly, about the yet-to-be-released Operating System/2 (OS/2).

The minute I mentioned PS/2 at COMDEX I was immediately asked my opinion about OS/2. From then on I heard a lot of grumbling and complaining and moaning and wailing and gnashing of teeth. Confusion and frustration are rampant; it's worth taking a look at some of the issues involved.

APPLICATIONS DEVELOPMENT

Most people I spoke with at COMDEX, both those in the industry and those from end-user companies, were full of questions about OS/2. Two major issues concern them: redevelopment or conversion of DOS applications for OS/2 and the installation of multiple operating environments within an enterprise. A secondary issue involves redeveloping applications for execution under the OS/2 Presentation Manager.

Software companies uniformly complained about conversion to OS/2. Varying degrees of pain are associated with the conversion, depending on how the particular application is written. The greatest agony comes from tightly coded assembly language programs, the least from well-behaved C programs (especially because C is the only high-level language that is currently available for OS/2).

Because of this pain, and the cost of performing the conversion, most software vendors wanted to know if they could simply hold off on OS/2 and force users to run the OS/2 compatibility box, the facility that allows one MS-DOS 3.x application to operate within OS/2. Software companies also asked if OS/2 could be ignored because of (a) the predominance of DOS 3.x in the installed base and (b) the availability of the so-called "control programs" for 386 machines.

OS/2 cannot be avoided and conversion is essential. Almost 10 million IBM and IBM-compatible desktop machines have been sold to date. About 4 million of them have either an 80286 or an 80386 processor; 286 machines are currently the big seller. That means about 40 percent of the installed base and an even greater percentage of new machines will be OS/2-compatible. New applications will certainly exploit the facilities that the 286/386 and OS/2 combination can deliver. Therefore, ignoring the new operating system would be long-term suicide.

The opposing argument holds that even though 40 percent or more of the machines can run OS/2, most will not, opting for the already well-understood and less-expensive DOS 3.x ($125 versus $325 for OS/2). That will be true as long as (a) no major applications exploit the power of the 286 or 386 processor and (b) as long as no one wants or needs to run two tasks concurrently. I, for one, do not believe that this is a realistic scenario.

As for the support of multiple operating systems in an enterprise, no microcomputer manager with a clear head would voluntarily decide to add to the confusion inherent in providing support for a second environment. Once a compelling application is introduced, however, the manager will be left with no choice. A dual operating system environment will become a reality until all 640KB-bound machines and applications either become obsolete or simply vanish.

The Presentation Manager and Microsoft Windows are another story. The end-user companies do not seem particularly to care about them one way or the other. If a graphical environment is appropriate, they will use it; if not, they won't bother.

Software developers, however, are really angry and frustrated about the Presentation Manager because its applications program interface (API) is not the same as the one for Windows. This means that existing Windows programs need to be converted. That represents a broken promise from Microsoft, which had long ago said that Windows was a migration path for applications, a calm sea beneath the storm of changing operating systems.

Because *PC Tech Journal* has not yet had a chance to examine the specification for the Presentation Manager, I am unable to decide how mad we

should be at IBM (which was clearly the "big OEM" pushing Microsoft in the new direction) for these changes. If the new API works to the applications developer's benefit, then the changes are simply frustrating. If no clear reason exists for the new API, then we can be justifiably furious.

Until the specification becomes available for us to draw a conclusion on it, applications developers who have not yet invested in Windows development should wait for the Presentation Manager—unless the application involved is marketable on machines without at least the 286. As mentioned above, as interesting and useful Presentation Manager–based applications become available, end-user companies will undoubtedly buy the required operating software.

HOW MUCH?!?!?

The strongest argument against OS/2 is its price of $325 for the Standard Edition (which in version 1.1 will include the Presentation Manager). Meanwhile, the price of DOS has been creeping up; it was $95 for version 3.2 and just jumped to $120 for 3.3. Still, OS/2 is three times as expensive as its predecessor. IBM took some of the sting out of that pricing for its larger customers by announcing volume purchase agreements and right-to-copy licensing, but that is not enough to get the price of OS/2 down to $100 per copy.

I think the price *is* too high. In fact, I think IBM will be forced to lower it if it wants to get a high degree of OS/2 penetration in its target market.

Getting the Standard Edition of OS/2 installed should be very important to IBM if it is serious about the Extended Edition with built-in communications and data-management features and if it wants to reduce its own software development costs. Although IBM is not highly regarded for its applications, the company has repeatedly stated that software would increasingly contribute to its revenues (which means it intends to produce more). I would rather see IBM concentrate on building better applications and putting the operating system in the box, bundled "for free" with every machine.

HARDWARE STANDARDS

If the software problems are frustrating, the apparent change in the hardware standard is confusing. Most of the people I spoke with thought the PS/2 family standards (Video Graphics Array, Micro Channel, 3.5-inch diskette) were good ones. The problem is that the pricing of the IBM offerings, while attractive relative to previous IBM machines, is not compelling when compared with the compatibles market or, worse, with Apple. None of the IBM machines represents a "clone-killer" or even a "clone-basher."

That leaves IBM in a peculiar position. It has clearly listened to its most important target market, its own mainframe customers, and responded with machines, software, and future plans that they should appreciate. It is not immediately clear, however, that the PS/2 family is a good choice for the vast universe of small- to medium-sized businesses. The "old" PC standard is quite lively and practical for that market; it can be made even more attractive with VGA clones and 3.5-inch diskettes, even if the Micro Channel is ignored for the moment.

If the advances in the PS/2 family were just hype, then the original PC standard would undoubtedly prevail. That is not the case; the new ideas are good ones. Thus, we are left with a desirable, new standard on the one hand and a cost-effective, predominant standard on the other.

Predicting how fast the new standard will be adopted is risky. Companies like Compaq, AST Research, and others are most assuredly working on machines that meet the PS/2 standard; availability of those products will accelerate the movement of the industry away from the PC. Nonetheless, the market will continue to support both standards for some time to come, a fragmentation that will certainly complicate decisions for many buyers.

A NOTE FROM COMDEX

COMDEX is usually a good place for an editor to check the pulse of the industry. Last year's two shows had weakened pulses, a reflection of a two-year slump in the desktop computer business. This year, the pulse was strong.

Attendance was clearly up, and the crowd exhibited a certain eagerness and excitement. That's the first sign of health: these busy people would not bother to attend if they were not going to make serious decisions sometime soon. Exhibitors seemed happy to be there as well, and that's a good sign.

Nonetheless, COMDEX/Spring offered very little in the way of new products or concepts. I saw only one product that really knocked me out: NewsViews, an accounting package from Q. W. Page Associates.

The *PC Tech Journal* audience might find accounting software out of the mainstream, but NewsViews is interesting because it redefines computer-based accounting in exciting ways. It is easier to use than most accounting software, but at the same time it does more work for the user. What I like is that a traditional, entrenched application has been turned on its head and a major step taken forward.

That is a valuable lesson for everybody to consider. Getting the computer to do more of the work while we do more of the thinking is a worthy goal.

—*WF*

MACINTOSH: YEA OR NAY?

As we go to press, we have received almost 1,600 ballots in response to our question "Do you think the new Macintosh machines will be important to your company?" (see "Mac II Attack," Directions, Will Fastie, June 1987, p. 9). The tally so far:

Yes	49.7%
No	50.0%

There were also four "maybe"s.

Although this quick study is not statistically projectable to our readership, it certainly is interesting. By any measure, a response of almost 50 percent from an audience who is primarily engaged in IBM and IBM-compatible work is astounding and reflects the stronger position in which Apple now finds itself.



—*WF*

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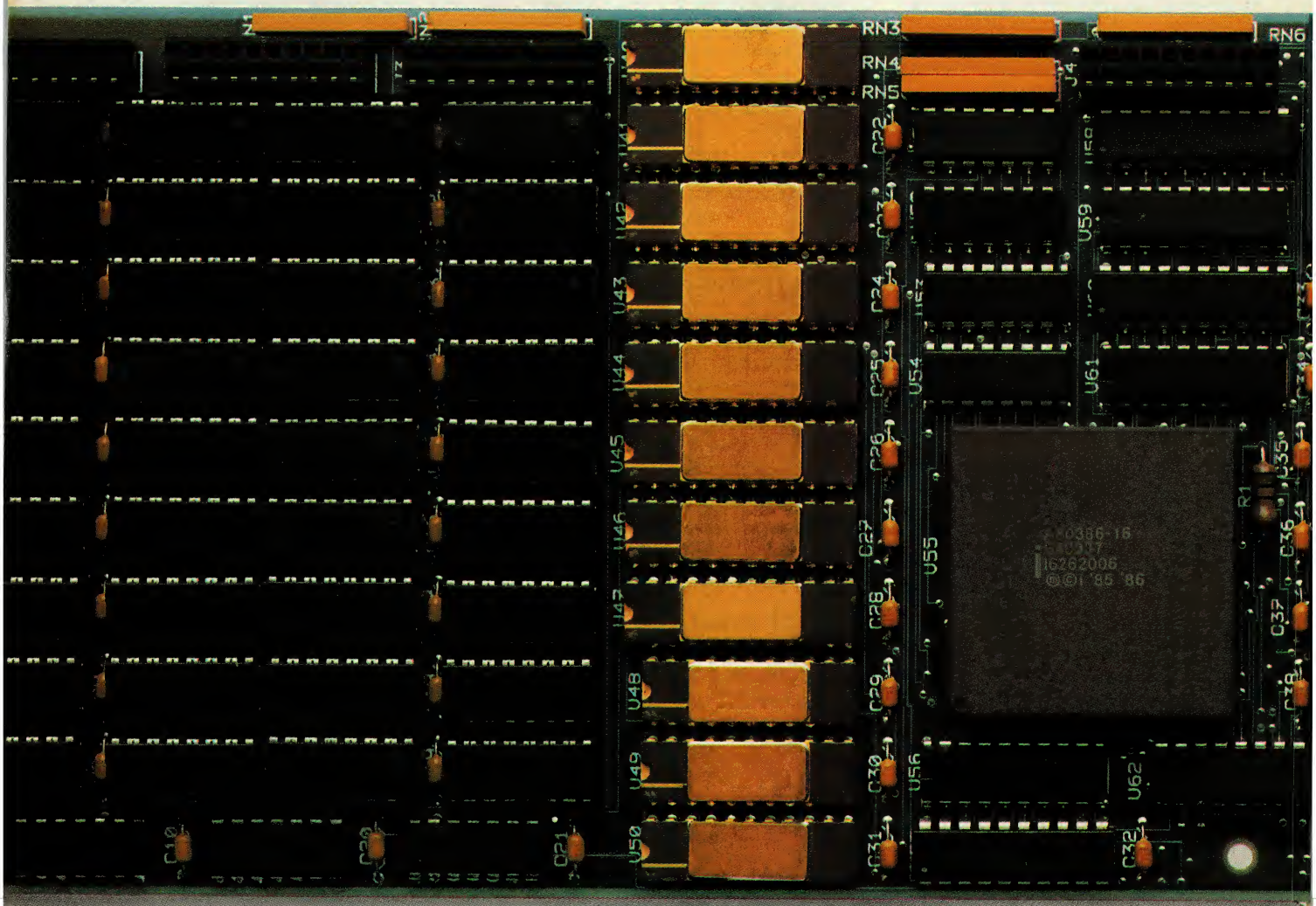
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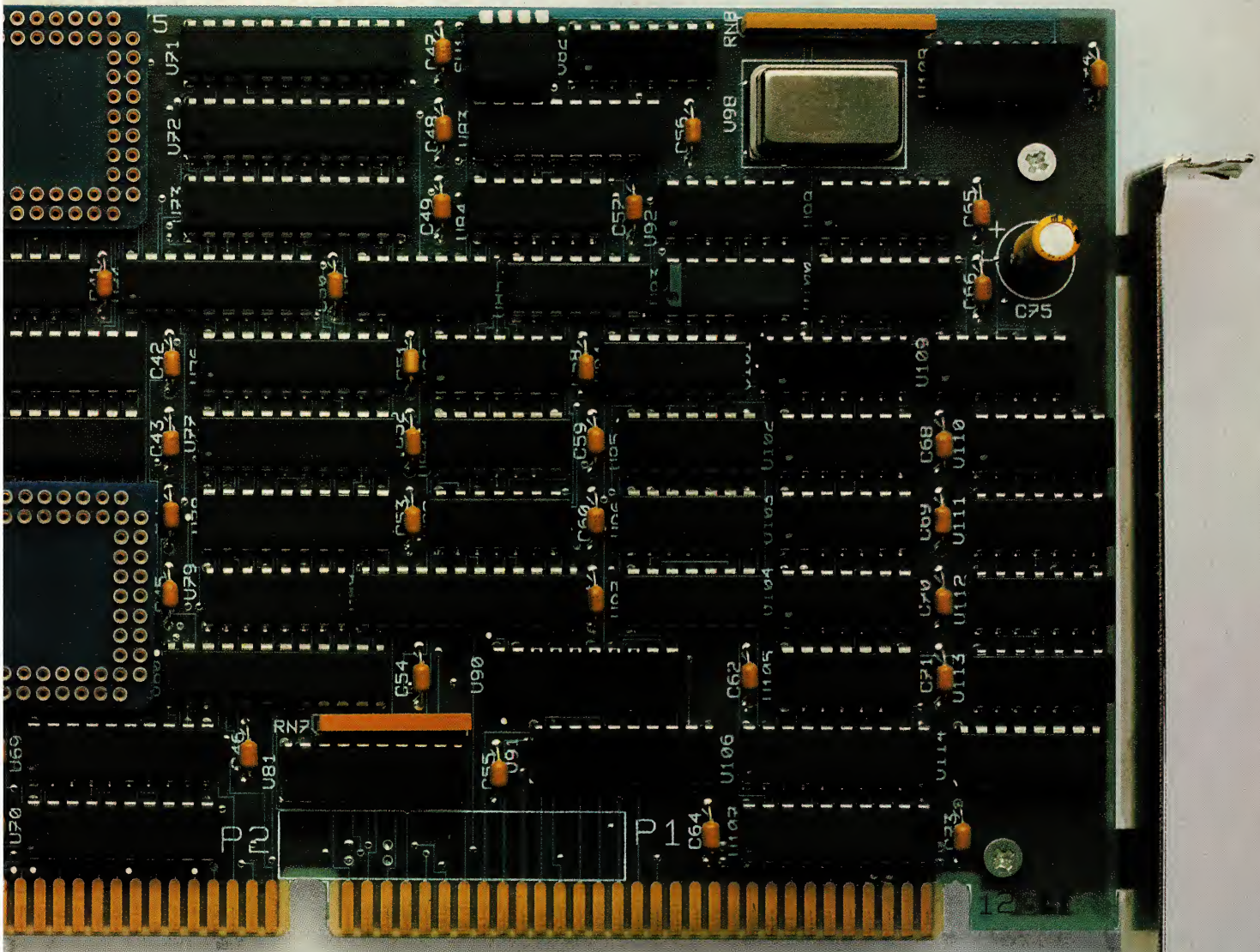
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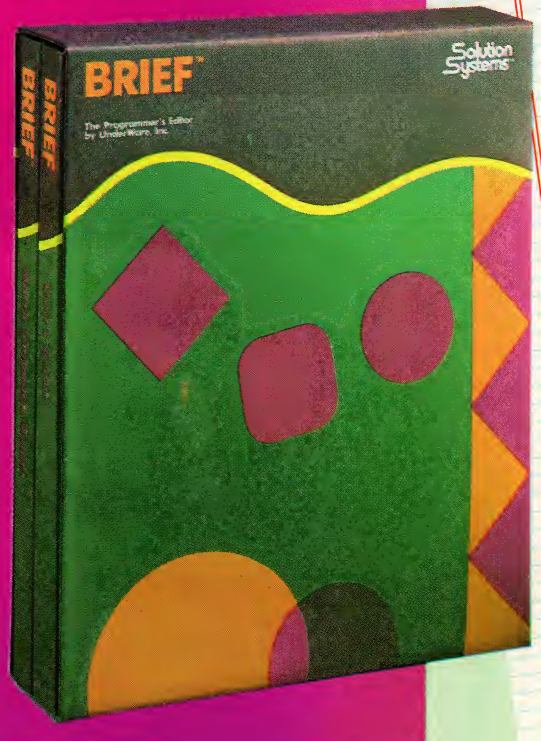
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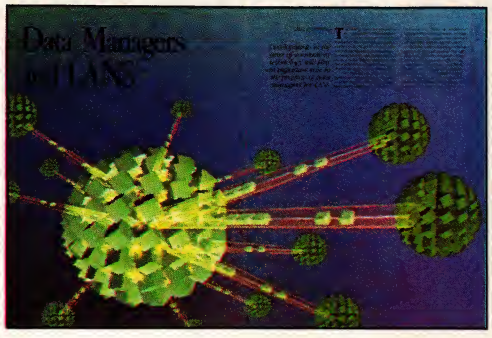
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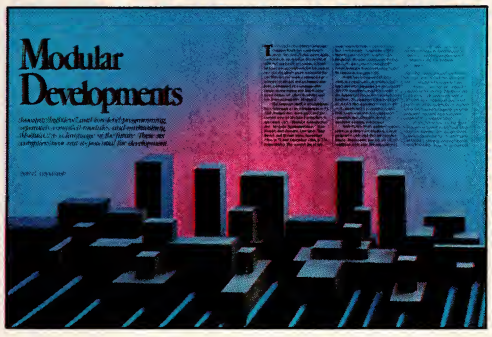
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LOCKING OUT DUMMIES

"Data Managers and LANs" (Dave Browning, May 1987, p. 54) describes an order-entry algorithm for record locking that is designed to lock an inventory record for the "briefest possible time" (figure 4 on p. 65). As presented, the algorithm will safely handle simple orders, but will not stock status inquiries. Such inquiries usually are essential to any order-entry system.

For an inquiry to be handled properly in a multiuser system, a way of temporarily reserving inventory should be provided. Without it, a dummy order must be placed to guarantee that the amount requested is actually available, even if there is sufficient quantity on hand (QOH). (Otherwise, an intervening order might "steal" the inventory while the inquiry is in process.) However, dummy orders can compromise system integrity.

Temporary reservations can be implemented with a separate file of reservation records. In the relational data model, an inquiry for *n* items could be made by:

- locking the inventory record and the reservation file;
- joining the reservation file to the inventory record in order to calculate total reserved stock and remaining stock available;
- creating a new reservation record of *n* items if sufficient stock is available to satisfy the inquire;
- removing the locks.

Reservation records should be canceled by their "owner" at the conclusion of an inquiry session. In addition, if reservation records are time-stamped with a reasonable "hold until" time, then an automatic fail-safe process can periodically cancel expired records, thereby maintaining system integrity.

A further improvement is to add a back-order file and an automatic procedure for filling back orders in priority order when reservations are canceled.

Although the article was a good overview of a complex subject, it would have benefited from a discussion of the special problems of failure recovery in a network environment.

John Navas II
Foster City, CA

Mr. Navas's point is well taken. The order-entry system used in this article was designed to illustrate the problems of networked data managers and was deliberately kept simple. Any complete order-entry system should reserve items and handle back orders.

Normally, procedures for failure recovery are implemented by the hardware and operating system. The most the data manager can do is provide transaction logging so that when a failure occurs, incomplete transactions can be backed out.

—Dave Browning

PECULIAR RANKING

Your March 1987 article on Modula-2 compilers ("Modular Developments," John T. Cockerham, p. 114) contained gross inaccuracies. The description of our PCollier Systems Modula2-PC bears little resemblance to the real product. For example, contrary to what your article says, we do support a large-memory module, multitasking, register access, in-line native 8087 code, .EXE files, sound support, and communications port access. In addition, the numbers for compile times are very inaccurate (showing our compiler to be many times slower than it actually is).

Peter Collier, president
PCollier Systems
Tucson, AZ

Because Mr. Collier's letter did not mention specific problems with the article, PC Tech Journal *called on Roger Flandreau, manager of software development for PCollier Systems, to detail his company's objections. The following clarifications and corrections should be made to table 1 of the article (Compiler Specifications, p. 120).*

- *Multitasking is available, but the library procedure* **StartProcess** *that Wirth defines is not provided.*
- *PCollier produces .EXE files, not COM. The .EXE files are produced, as stated in the text of the article, by a command-line switch when the linking loader is invoked.*
- *Interrupt-driven communications port I/O is available through the FILES module, but is not documented.*
- *All DOS calls are available through a procedure interrupt in module DOS (a low-level interface). A higher-level spawn function is not provided.*
- *Register access can be achieved through a register record (which the runtime system loads into registers before executing a software interrupt), but no syntactic construct is available to allow register access in individual Modula-2 statements.*
- *A BEEP procedure accesses the speaker, but lacks the versatility of the SOUND procedure of Interface Technologies' Modula-2 SDS.*
- *The manual lists no comprehensive COM port access routines.*
- *The following features are available as extra-cost options to Modula2-PC: in-line 8087 support, binary-coded decimal (BCD) arithmetic, runtime debugger, and customization.*
- *The editor uses the function keys and a key command set similar to the IBM Personal Editor.*

Since John Cockerham's article was published, PCollier has released version 2.0 of its compiler. It has not been reviewed by PC Tech Journal.

—DM

The PCollier compiler uses an unusual technique to allow large activation records. Most other compilers use the processor's stack pointer (SP) and base pointer (BP) to pass parameters and

hold the activation records in procedure calls. The drawback to this approach is that only 64KB of the stack for all active procedures is allowed without real acrobatics on the compiler's part. PCollier's compiler uses SP only for keeping the return addresses and passing parameters. DS is used as the activation record pointer, which allows very large activation records. This method significantly increases the overhead involved in entering and exiting a procedure. The poor performance of the compiler in some benchmarks is attributable to this overhead.

Although the code fragments published showed results being stored through BX, this compiler does not use BX exclusively for storing results. It eschews the REP MOVSW optimization for structure assignment because structures can be an odd number of bytes and are not word-aligned.

I stand by the timings for compilation of the benchmark program. Mr. Collier's letter cites no specific compile times, but the differences must be due to different hardware configurations. (Version 2.0 of Modula2-PC is much better. The code for the cardinal arithmetic benchmark no longer contains NOPs, but the procedure-calling overhead is still very high.)

—John Cockerham

I am sorry that in the March 1987 article, "Modular Developments," John Cockerham should suggest that the omission of the immensely useful GOTO is a desirable feature of Modula. Certainly the GOTO can always be replaced by "structured logic," but, as Richard Schwartz and Robert Shostak point out in their column in the same issue ("What Computers Cannot Do," Expert Consultant: *Applied AI*, p. 177), any program can also be implemented on a Turing machine, and, in my opinion, a language without a GOTO is about as useful as a Turing machine.

I have flirted with most of the high-level languages (HLLs), but none has wooed me away from assembly language, mainly because they all suffer from irritating restrictions of GOTOs; none encourage the use of well-documented code the way assembly language does. For example, if I say **jmp end_lin**, I know precisely what will happen, but if I try to use structured programming techniques with anything interesting, I always get a deeply nested IF . . . THEN . . . ELSE HOWEVER . . . MAYBE set of loops, and I never feel entirely confident that I have not omitted some vital curly brace or semicolon, or even that the compiler will interpret the rules as I do.

I would probably put up with this if I had found that HHLs made my job easier. My experience has been that most of the time is spent establishing the appropriate algorithm and that while HHLs certainly lead to a much shorter source file, they do not make the job much faster, nor is the result significantly easier to follow or maintain. The one thing I can guarantee, however, is that the finished program will be five times as long, and, at best, three times as slow.

Certainly GOTOs can be misused, and, as I know firsthand, if you want to write totally unmaintainable code, the FORTRAN assigned GOTO is without peer. Used properly, however, GOTOs can make a complex program much easier to follow. I consider that structured logic is two-thirds fad and only one-third common sense, and I believe that the clarity of a program is deter-

Continued on p. 21

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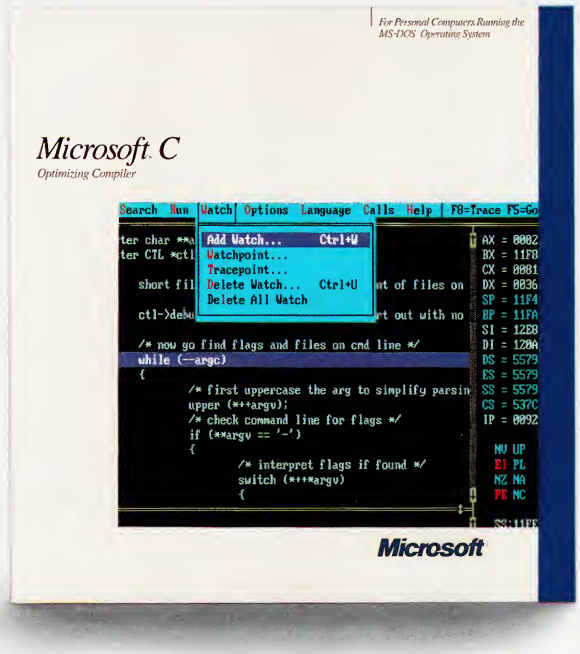
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mined by the programmer, far more than by the structure of the language. It is a pity when one man's paranoia can shackle what would otherwise be a potentially useful language.

Roger Riordan
East Brighton, Australia

POWER SHAFT/2

Regarding Will Fastie's column on the IBM Personal System/2 ("Round/2," Directions, May 1987, p. 9), I think his view is a bit lopsided in praising IBM for its innovative approach in alienating all PC users. The innovation that IBM has come out with is nothing new. For example, the Micro Channel architecture, as was stated in the column, has been used extensively in minicomputers for years in one form or another.

Why would I, as a systems designer and engineer, want to buy a product that forces me back to the mercy of a single vendor?

As far as I am concerned, we have been modifying personal computers for more than three years to be used with XENIX as our standard multiuser, multitasking environment. Finally, IBM has realized the need to offer something for this market segment.

But, why do we need another potpourri operating system—one that is made from a little bit of this and a little bit of that? Why does IBM refuse to embrace an operating system standard—specifically, UNIX System V?

In his column, Mr. Fastie mentions that IBM's VGA offers enhanced graphics at a competitive price-to-performance ratio. What about today's prices for EGA-compatible monitors and adapters? Hardware is a commodity, and prices will continue to decline for this current configuration.

Why has IBM not offered SCSI or ESDI to enhance the worst performer of any system. Bus arbitration is unimportant when intelligent I/O controllers are available to help unburden the CPU. Furthermore, XENIX and UNIX are hardware-interrupt driven so that they themselves control all requests from peripherals based on priorities.

Diskettes are unimportant, regardless of format. The only time I use one is to load software onto my hard disk. I back up everything with streaming-tape cartridges, so I don't care if they put the original software on a bagel.

About all the add-on options . . . I happen to like mine. I refuse to subject myself to IBM's whims and fancies. I believe the PS/2 is IBM's retaliation against the very people who have pushed the personal computer industry far beyond what it would have been if left to the discretion of IBM.

I do feel, however, that IBM has the power to direct this market, and it probably will. I only wish that IBM would do it not just for the money, but for the sake of science, technology, and the good of all computer users.

Norman P. Fuchs,
Norand Technologies, Inc.
Port Jefferson, NY

CHECKING A CRC ERROR

I am writing with regard to the article on the XMODEM protocol ("Binary Transfer," Ronald Florence, March 1987, p. 144). This article is of special interest to me because I am writing a program to allow file transfers between the PC running DOS and the DEC VAX 11/750 running under a UNIX operating system. I discovered one error in the C source code listing on p. 154. According to the explanation of the XMODEM protocol in the sidebar by Augie Hansen (p. 147), **chksum** is ANDed with 255. Therefore, line 63 (published as **chksum % = 256;**) should read **chksum &= 255;**.

David C. Cox
Warrenton, VA

I am pleased to hear that Mr. Cox found the article and code useful. Yes, the sidebar and the listing give different code for the cyclic redundancy check (CRC); but, in fact, it makes no difference whether the code reads ***chksum*** *% = 256; or* ***chksum*** *&= 255;—the results come out the same.*

—Ronald Florence

WHAT SAY SAYWHAT?!

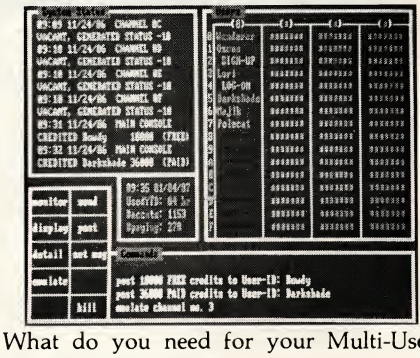
I was pleased to discover your review of our screen-design software, Saywhat?!, in the May 1987 issue (Product Watch, Steve Johnson, p. 201). The reviewer has obviously used Saywhat?! version 3.0 and I appreciate his fair, honest, and favorable review.

I would like to clarify a few items. Contrary to what Mr. Johnson says, the RUN command is not necessary to display the Saywhat?! screens from dBASE III PLUS programs. RUN has not been required since March 1986, when our language-independent version (3.0) was released. The documentation for Saywhat?! 3.0 clearly shows the simple statement in dBASE syntax (similar to most other languages) that pops up a screen. Saywhat?! screens can be displayed from dBASE III PLUS as fast as 10 screens per second; this would be im-

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possible with the 1.2-second overhead of the dBASE RUN command.

For some languages (such as Microsoft C, Fox Software's FOXBASE+, and Borland's Turbo BASIC) and the dBASE compilers (such as Nantucket Software's Clipper and Wordtech System's Quicksilver) that write to the screen, we provide source code and linkable object code modules that allow access to interrupt 10H, thus permitting the use of Saywhat?! screens without using an EXEC function.

For Turbo Pascal programmers, we provide a method of incorporating Saywhat?! screens into the .COM file at compile time and displaying screens without the use of the resident display program. Screen display rates exceeding 30 screens per second are possible using this method.

Version 3.6 of Saywhat?!, which was released in May 1987, adds a number of significant new features, including a screen library manager that will combine as many as 100 screens into one file, monochrome emulation for testing the appearance and effectiveness of screens developed on color systems (but for use on both), and the ability to define moving bar menus in any Saywhat?! screen. Menus can be any size, either vertical or horizonal, and require only one line of code to activate in almost any language, including DOS batch files. In addition, Saywhat?!'s moving bar menus return validated user choices to the calling program in the programmer's choice of numbers, characters, or words.

Richard Matzinger
The Research Group
San Mateo, CA

My review was based on Saywhat?! version 3.0, and I did mention that the RUN command is not always needed. (In fact, I presented an example in C to pop up a screen using the memory-resident program, which is functionally equivalent to the dBASE example in the Saywhat?! manual.) Those dBASE programs using Clipper, however, do require the RUN command because Nantucket bypasses the normal DOS interrupts. This was my major complaint with the product. As a Clipper developer, I would prefer to have a .OBJ file with source code provided; this would replace the memory-resident program and the POP.COM file, which is invoked with the RUN command, in Saywhat?!. I found no OBJ or source-code modules in my review copy.

—Steve Johnson

EGA NEEDED PLASMA SWITCH

I recently purchased a Compaq Portable III computer along with the expansion unit for my Intel Above Board 286 and IBM Enhanced Graphics Adapter. When I attached my EGA board to the expansion unit, the plasma display as well as my IBM Enhanced Color Display would not work properly. No dealer I spoke with could help me. I even called Compaq in Texas, but was referred back to the dealer.

It was in your review of the Portable III ("Portable Pacesetters," Jim Shields, May 1987, p. 74), which packed more useful information in a few pages than is in all of the operator's documentation supplied with the machine, where I found the answer to my problem. Jim Shields was thorough and very exact, particularly with the information about using an EGA monitor with the plasma display: "Switch 7 of the system board switch block must be turned off to indicate that the plasma display

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For example:

```
int count=0;          becomes    far int count=0;

main (argc, argv)                main (argc, argv)
int argc;                        int argc;
.                                .
.                                .
.                                .
```

If you still run out of room in DGROUP, the new Microsoft C Optimizing Compiler Version 5.0 has another feature to keep your data access fast. The first step is to divide your external data into two files, data1.c and data2.c. The first file, data1.c, contains all of your DGROUP data such as initialized static data and variables you explicitly declare NEAR. The second file, data2.c, contains all of the data you declare FAR.

Microsoft C 5.0 puts all of the data declarations in the second file into a single new segment. Now create an include file using the #pragma same_seg to tell the compiler that all of the variables in the data2.c are in the same segment. Including this file in each module tells the compiler to load the new segment in the ES register and use the ES register when referring to variables in data2.c. Now references to data in both data1.c and data2.c will be faster NEAR references.

These are the kinds of features coming in the Microsoft C Optimizing Compiler Version 5.0 that will make your code faster than ever before.

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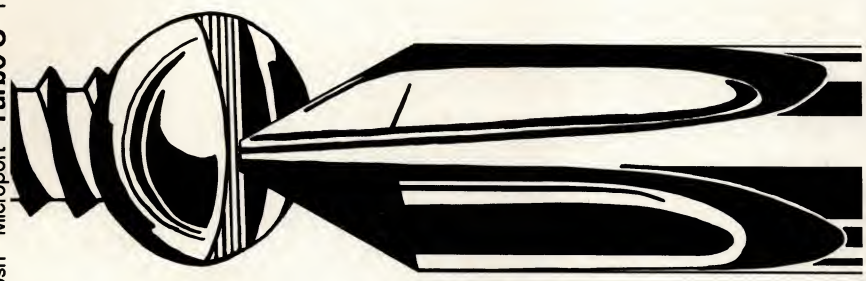
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adapter is to be placed in monochrome mode when the system is initialized." Thank you. My EGA board works great.

Joseph Bentivegna
Franklin, MA

VEDIT VINDICATION

We thank PC Tech Journal for including VEDIT PLUS in its recent review of text editors ("Editors as Programming Tools," Mark L. Van Name and William B. Catchings, May 1987, p. 160).

Unfortunately, several inaccuracies crept into the feature comparison (table 2 on p. 164). Specifically, VEDIT PLUS does have backward searching, allows single replacements, allows case-sensitive or -insensitive search, supports prompts in macros and allows case changing. Also, its price is $185.

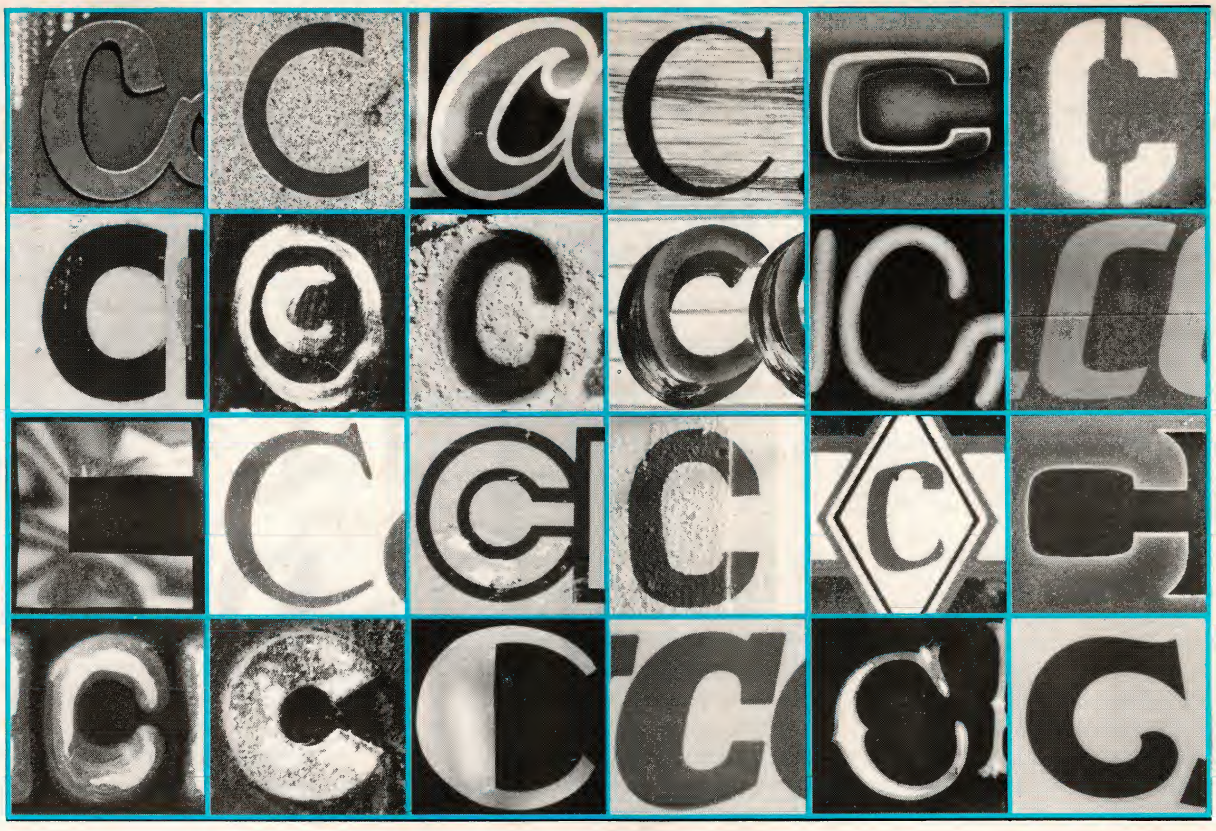
The statement that VEDIT is not well-integrated with the PC is most surprising. The example given was that the back-tab function was assigned to the Home key. We chose this assignment because it is used by some of the best-selling PC word processors and by Borland's Sidekick. The issue is really academic because the keyboard layout is completely user-changeable.

We were surprised to read that the installation program for changing the keyboard layout was considered cumbersome. This statement seems very unjust since VEDIT PLUS is the only editor that lets a nontechnical person change the keyboard layout. The installation program prompts with each edit-function name and the user simply presses the desired key for it or Return to keep the old assignment.

The documentation was criticized because the PC key mapping is hard to find. Because the keyboard layout is so easy to change, virtually every user changes it to some degree. Therefore, the documentation says to press the [REPEAT] key instead of saying to press Ctrl-R. We do not force users to adopt a preset keyboard layout. The on-line help instantly displays the current keyboard layout. Therefore, it would be inappropriate to clutter up the manual with a preset keyboard layout.

We consider several other criticisms a matter of personal preference that can be resolved during installation. For example, they state that search and replace are performed on the currently loaded segment unless global operation is specifically requested. This actually depends upon the installation—you can have it either way.

In summary, we feel that the reviewers assumed that because VEDIT has



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Theodore Green, president
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Ann Arbor, MI

NO INTERFERENCE, PLEASE

Your publication and others have featured articles reviewing the performance of IBM PCs compatibles. Unfortunately, in most cases, the reader has not been informed about the required Federal Communications Commission (FCC) certification for the sale and use of personal computers. Many advertisements have claimed "FCC approved," which is meaningless for computing devices. Class B computing devices are those computers and peripherals that are marketed for use in a residential environment. They must be tested for compliance with FCC radio-frequency emission limitations and have an FCC certification granted before marketing begins. This includes an FCC identification number visible on the exterior of the device at the time of sale.

Noncertified computers frequently cause interference to television and radio reception at a significant distance. In addition, the same conditions that allow radio-frequency emissions to escape the computer *also* allow strong radio signals from nearby transmitters (such as citizens' band, amateur, land mobile, or broadcast) to interfere with the operation of the computer.

The FCC has been conducting a vigorous enforcement campaign for more than a year now and has issued fines totaling several hundred thousand dollars to those who manufacture, assemble, advertise, or offer to sell or lease, sell, lease, ship, distribute, or use uncertified personal computers. Those who purchase and use uncertified computers at home are at risk. In addition, those users who cause harmful interference to television or radio reception by the use of a certified computer must cease use immediately until the interference is eliminated.

Anyone with a 300- or 1200-bps modem may verify the certification status of any personal computer by calling the FCC Public Access Link (PAL) at 301/725-1072. This service allows direct access to the FCC database. It is user-friendly and menu-driven. One enters the FCC ID for the computing device in question and is informed about its certification status. Each access is limited to five minutes to ensure maximum availability to other users.

J. J. Freeman, national coordinator
Computer Marketing Enforcement
Federal Communications Commission

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All letters to the editor should be directed to Editor, *PC Tech Journal*, Suite 800, 10480 Little Patuxent Parkway, Columbia, MD 21044. Correspondence also can be submitted over MCI Mail to PCTECH.

Although *PC Tech Journal* cannot publish all letters received, every effort is made to answer as many as possible. Please keep letters brief and to the point, and include name, mailing address, and telephone number; when a letter is lengthy, a diskette is appreciated.

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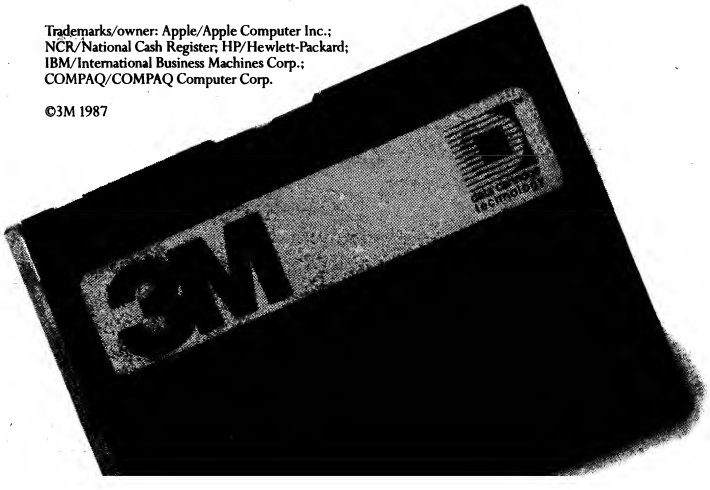
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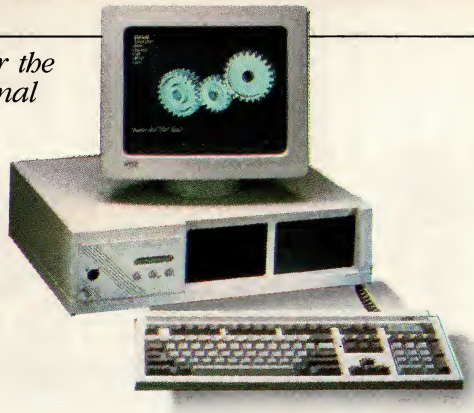
Call (800) 423-3280 for a list of data cartridge drive manufacturers.

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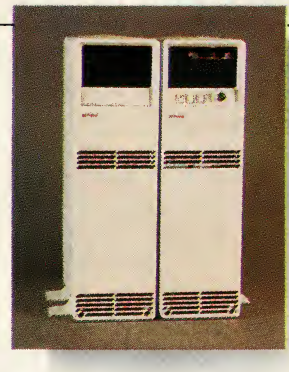
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16-MHz WYSEpc 386 model WY-3216 from Wyse Technology



Prime EXL 316 supermicrocomputer

SYSTEMS

A family of IBM-compatible personal computers based on the Intel 80386 and 80286 has been announced by **Wyse Technology**. The four products include the 16-MHz **WYSEpc 386 WY-3216** and three models of the **WYSEpc 286** family: the 8-MHz **WY-2018**, the 12.5-MHz **WY-2112**, and the 12.5-MHz, zero-wait-state **WY-2214**. The modular system architecture of these two families has a passive backplane design with the CPU mounted on a self-contained, plug-in circuit board. The design provides an upgrade path, allowing users to increase system performance in the future by simply changing CPU cards. A Wyse-designed LCD system-status display and front-panel controls are standard features on all systems. Disk-caching software is included for improved hard-disk operation along with software for expanded-memory emulation to access memory in excess of 640KB.

Wyse also announced the **WY-995**, an intelligent multiuser interface board that allows users to connect up to eight peripheral devices to AT-compatible systems. WY-3216-01 with one diskette drive, $3,799; WY-3216-40 with a 40MB hard disk, $4,999; WY-2108-01 with one diskette drive, $1,599; WY-2108-20 with a 20MB hard disk, $2,099; WY-2112-01 with one diskette drive, $2,299; WY-2112-40 with a 40MB hard disk, $3,499; WY-2214-01 with one diskette drive, $2,799; WY-2214-40 with a 40MB hard disk, $3,999; WY-995, $699.
Wyse Technology, 3571 N. First Street, San Jose, CA 95134; 408/433-1000
CIRCLE 302 ON READER SERVICE CARD

Four models of 80386-based microcomputers are available from **Advanced Logic Research, Inc.** Designated the **ALR 386/2**, this family has full-track disk caching designed on the controller and features an advanced hard-disk controller that performs with a 1:1 interleave factor similar to the IBM Personal System/2 models. All models feature an ALR-designed system board with a Phoenix BIOS, 32-bit RAM, a 16-MHz 80386, a socket for a 10-MHz 80287, an enhanced keyboard, one serial port, one parallel port, and eight expansion slots. **Model 10** has 1MB RAM (expandable to 2MB on the system board). **Model 40** features 2MB RAM, a 40MB hard disk (with an average access time of under 30 ms), and EMS/multitasking software. **Model 80** and **Model 130** are the same as the



ALR 386/2 from Advanced Logic Research, Inc.

Model 40, but with a 70MB and a 130MB hard disk respectively. Model 10, $1,990; Model 40, $3,990; Model 80, $4,690; Model 130, $7,299.
Advanced Logic Research, Inc., 10 Chrysler, Irvine, CA 92718; 714/581-6770
CIRCLE 303 ON READER SERVICE CARD

Significant additional performance for disk- and number-intensive applications is possible on the **Compaq Deskpro 386** from **Compaq Computer Corporation**. The Deskpro 386 now accommodates the optional Intel 16-MHz 80387 and comes with software for disk caching, which works in conjunction with the Compaq Expanded Memory Manager (CEMM) to enhance performance of hard-disk drive operation. CEMM allows users to address memory beyond the 640KB memory limitation of DOS with applications that follow the Lotus/Intel/Microsoft expanded memory specification (EMS). Depending on the application, disk caching can increase performance as much as 50 percent. 80387 option, $999; upgraded system board with an 80387 installed (through December 31, 1987), $999.
Compaq Computer Corporation, 20555 FM 149, Houston, TX 77070; 713/370-0670
CIRCLE 301 ON READER SERVICE CARD

A multiuser supermicrocomputer that simultaneously runs UNIX and DOS has been introduced by **Prime Computer, Inc.** Based on Intel's 80386, the **Prime EXL 316** runs Prime's implementation of AT&T's UNIX System V.3 operating system. The system executes at 3.2 millions of instructions per second (mips) at a spped of 16 MHz when running typical UNIX operations. The Prime EXL 316's CPU provides 64KB of combined instruction/data cache memory and virtual memory with paging. The Prime EXL 316 accommodates up to 58 asynchronous lines to terminals, printers, and other systems. The supermicrocomputer communicates with Prime 50 Series superminicomputers as well as other vendors' host systems via standard Ethernet running TCP/IP (transport control protocol/internet protocol) software. Prime is developing Systems Network Architecture (SNA) connectivity between the Prime EXL 316 and IBM systems. Standard configuration includes Prime's implementation of AT&T's UNIX System V.3, 2MB of RAM, a 90MB hard disk, a 60MB streaming-tape back-up drive, and 10 asynchronous lines. Prices start at $23,900.
Prime Computers, Inc., Prime Park, Natick, MA 01760; 800/343-2540; in Massachusetts, 800/322-2450
CIRCLE 304 ON READER SERVICE CARD

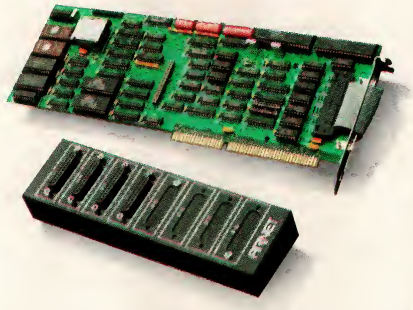


Televideo Systems' TELENIX-386 multiuser workstation (center)

A family of multiuser UNIX workstations that supports DOS, is being offered by **Televideo Systems, Inc.** The **TELENIX-286** and **TELENIX-386** workstations operate under Microport Systems' V/AT UNIX. DOS 3.1 and Microport Merge-286 or Microport Merge-386 are optional, allowing users to run both UNIX and DOS applications concurrently without having to reboot the system, enter special operating system commands, or switch software. The TELENIX-286 features a 1.2MB diskette drive, a 40MB hard-disk drive, 1MB of RAM, five expansion slots, and a 14-inch monitor. The TELENIX-386 comes with either a 71MB or a 150MB hard disk, 2MB RAM, 60MB streaming-tape back-up drive with disk controller, and eight expansion slots (including two, dedicated 32-bit slots). TELENIX-286, $5,995; TELENIX-386 Model 71, $8,995; Model 150, $11,500.
Televideo Systems, Inc., 1170 Morse Avenue, P.O. Box 3568, Sunnyvale, CA 94088-3568; 408/745-7760
CIRCLE 305 ON READER SERVICE CARD

CONNECTIONS

A line of serial port expansion boards for the IBM PC and 80386-based computers is being manufactured by **Arnet Corporation** as a low-cost alternative to local area networks (LANs). The boards provide the necessary hardware to transform PCs into multiuser systems; each board provides as many as eight extra serial ports to connect dumb terminals for additional users. Arnet boards work with more than 15 multiuser operating systems for PCs, including UNIX, XENIX, Pick, Concurrent PC DOS, THEOS, and Multilink Advanced. **Twinport** provides two serial ports that can be configured as COM1 and COM2 or as other COM ports for use with multiuser operating systems. **Multiport** comes with either four or eight serial ports, but only occupies one expansion slot. The four-port version can be upgraded in the field to eight ports using a piggyback board. **Smartport** has four or eight ports driven by an 80186 processor. Smartport boosts overall system performance by handling data transmissions to and from terminals and printers. The PC loads a block of data into the Smartport's memory and instructs it to send the data out to the terminal or printer, freeing the PC to perform

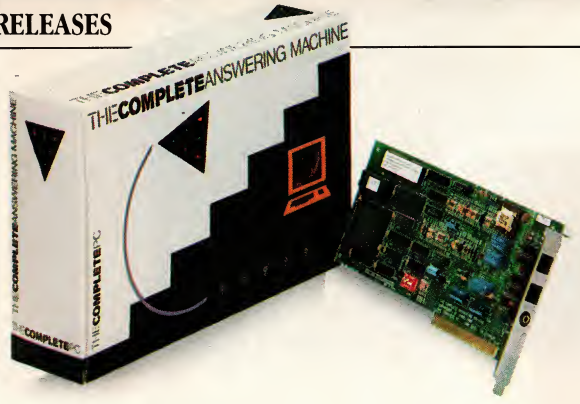


Arnet Corporation's Smartport-4 serial port expansion board

other tasks. Twinport, $269; Multiport-4, $495; Multiport-8, $735; Smartport-4, $995; Smartport-8, $1,295.
Arnet Corporation, 476 Woodycrest Avenue, Nashville, TN 37210; 615/254-0646
CIRCLE 312 ON READER SERVICE CARD

By providing a remote-programming facility, **GammaLink** has enhanced its **GammaModem** stand-alone 9600-bps (bits per second) synchronous modem. The remote-programming feature is designed to increase the modem's usefulness in large Systems Network Architecture (SNA) networks. This facility provides a variety of programming modes (such as the Hayes AT command set), front-panel switches, internal DIP switches, or remote programming from a site that is equipped with GammaLink's GammaCom Network Manager Software. All set-up parameters are stored in battery-backed RAM for security in the event of a power outage. GammaModem is compatible with three CCITT standards for synchronous communications: V.29 for 9600, 7200, and 4800 bps; V.27 for 4800 and 2400 bps; and V.21 for 300 bps. $1,495.
GammaLink, 2452 Embarcadero Way, Palo Alto, CA 94303; 415/856-7421
CIRCLE 314 ON READER SERVICE CARD

Used in conjunction with two hardware products, **MultiLink Advanced**, developed by **The Software Link, Inc.**, allows 80286-based machines to run PC applications in multiple sessions. A shared-processor multiuser and multitasking system, MultiLink Advanced requires the company's own **ATGizmo** and the **AboveBoard 286** from **Intel Corporation**. MultiLink Advanced allows as many as 17 applications/users to share the CPU (and resources) of a central host 80286-based computer. **MultiLink Advanced MTO** is a multitasking-only version of MultiLink Advanced that does not offer terminal support. **ATGizmo** is a card that attaches directly to the 80286 motherboard and remaps memory, letting current PC applications reside in as much as 8MB of extended memory. Intel's AboveBoard 286 is a memory board that supports both expanded and extended memory. With the three product combination, users can take advantage of both expanded and extended memory available with 80286 machines. MultiLink Advanced, $595; MTO, $195; ATGizmo, $335. AboveBoard 286 with 512KB RAM, $545.
The Software Link, Inc., 3577 Parkway Lane, Atlanta, GA 30092; 404/448-5465
CIRCLE 309 ON READER SERVICE CARD
Intel Corporation, Mail Stop CO3-07, 5200 N.E. Elam Young Parkway, Hillsboro, OR 97124-6497; 800/538-3373; in Oregon, 503/629-7354
CIRCLE 310 ON READER SERVICE CARD



The Complete Answering Machine from The Complete PC, Inc.



Quadram's StarLAN-compatible QuadStarter Kit

An intelligent answering machine for the PC has been introduced by **The Complete PC, Inc.** A voice-messaging coprocessor board, **The Complete Answering Machine** (CAM) operates concurrently with most PC applications and provides personal voice mail, advanced message handling and basic telephone answering functions. Using its on-board microprocessor, CAM digitizes the caller's voice and stores it on the computer's hard disk. Features include multiple voice mailboxes (allows each person in a office to have a private voice mailbox with the use of passwords), multiple greetings (can be stored on disk in a library), greeting override (allows incoming calls to begin recording immediately), special mailboxes (can be left for callers to leave confidential messages), call transfer, remote operation (can be used for listening to messages), outgoing-message recording, new-greeting recording, and remote control (can be used to change any CAM parameter from a touch-tone telephone). $349. *The Complete PC, Inc., 521 Cottonwood Drive, Milpitas, CA 95035; 408/434-0145*

CIRCLE 311 ON READER SERVICE CARD

An easy-to-install StarLAN local area network is available from **Quadram**. The **QuadStar** is first being offered with the **QuadStarter Kit** for first-time installations. The QuadStarter Kit includes: **QS-100**, a high-performance, half-card adapter; **QS-PH6**, a personal hub card adapter with six ports; 50 feet of cable; Tapestry, a networking operating system from Torus; Tapestry user's guide; an audio guide to networking, a "How To Get Your Networking" map; the QuadStar quick install guide; and a program guide to StarLAN and QuadStar. QuadStar adheres to the IEEE 802.3 1BASE5 StarLAN standard and has a data-transfer rate of 1 Megabits per second (Mbps).

The QS-100 and the QS-PH6 also are available separately and come with Tapestry workstation diskette, user's guide, and 25 feet of cable. The **QS-188** is an intelligent, full-sized adapter with an 80188 CPU on board and also comes with Tapestry diskette, user's guide, and 25 feet of cable. The **QuadStar Hub-12** is a full-featured, 12-port, stand-alone hub. The QuadStarter Kit, $1,095; QS-100, $375; QS-PH6, $575; QS-188, $495; Hub-12, $795. *Quadram, One Quad Way, Norcross, GA 30093-2919; 404/923-6666*

CIRCLE 319 ON READER SERVICE CARD

PERIPHERALS

Three add-in boards for the IBM Personal System/2 (PS/2) Models 50 and 60 have been developed by **Quadram Corporation**. The **QuadMEG PS/Q** is a memory board with a maximum of 2MB available using 256KB or 1MB SIMMs (single in-line memory modules). The QuadMEG PS/Q is compatible with Operating System/2 (OS/2) and can supply extended memory for programs using the protected mode of 80286 CPU, and software using the Lotus/Intel/Microsoft EMS. The Micro Channel ID is switch selectable, preventing any possibility of Micro Channel bus conflict with other expansion cards installed in the system. The QuadMEG PS/Q is supported by the PS/2 BIOS, which means that the board is recognized by a Model 50 or 60 at boot-up and does not require any additional configuration or driver.

The **Quadboard PS/Q** is a multifunction board for the Models 50 and 60. As much as 2MB RAM can be configured using 1MB SIMMs. The memory is bank-switched in 16KB blocks and can be switched to either extended or expanded mode. One bidirectional parallel port and one RS-232C serial port will be standard. Like the QuadMEG, the Quadboard PS/Q is supported by the PS/2 BIOS and the Micro Channel ID is switch selectable.

The **QuadPort PS/Q**, an I/O board for the Models 50 and 60, comes standard with one bidirectional parallel port and one RS-232C serial port. An optional upgrade will be available with two additional RS-232C serial ports with a special port-mounting bracket and cables. QuadMEG PS/Q: with 512KB, $545; with 1MB, $695. Quadboard PS/Q: with 0KB, $595; with 512KB, $745. QuadPort PS/Q, $395; two-serial-port upgrade, $195. *Quadram Corporation, One Quad Way, Norcross, GA 30093-2919; 404/923-6666*

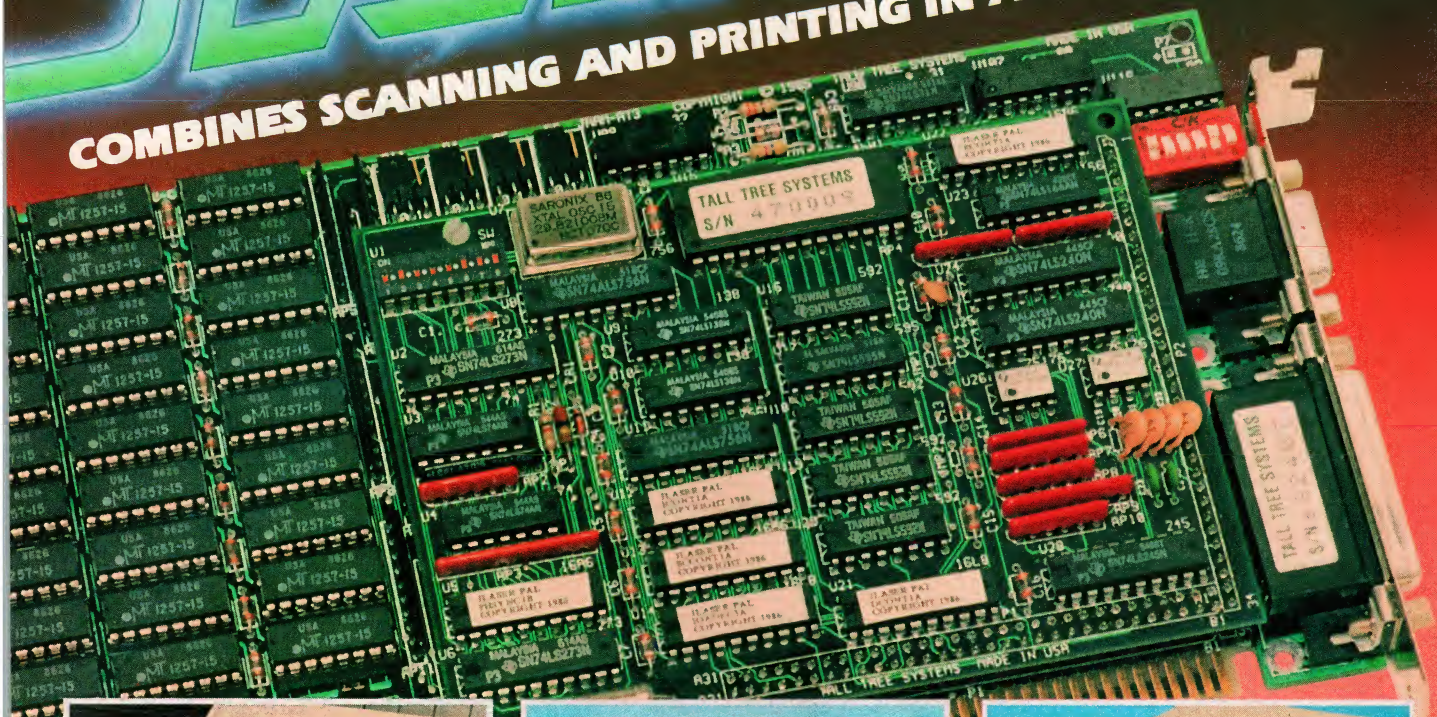
CIRCLE 343 ON READER SERVICE CARD

Three products for the IBM Personal System/2 (PS/2) have been introduced by **Alloy Computer Products, Inc.** The **Tape System/2** (TS/2), one of Alloy's Retriever products, is an internal tape drive back-up system. It uses a DC-2000-type, 40MB tape cartridge, has error-correcting capabilities, and is compatible with the industry-standard QIC-4 (Rev. D). The TS/2 fits inside the second diskette drive slot of the PS/2 and comes with bezels to fit each model. **ResQNET**, a TS/2 back-up software package with support for Novell LANs, is optional.

The **HI/2**, Alloy's host interface adapter for the PS/2 Micro Channel bus architecture, provides an interface between Models 50, 60, and 80 and the existing PC expansion bus used in Alloy's PC-XBUS and PLUS4. The PC-XBUS is a 12-slot expansion chassis used to interface multiple PC-SLAVE cards, the heart of Alloy's PC-PLUS multiuser, multiprocessor LAN system. PLUS4 is a small, preconfigured version of PC-PLUS that provides a four-user LAN and includes a built-in 40MB tape cartridge drive. Both the PC-XBUS and PLUS4 connect directly to the PS/2 Model 30.

JLASER PLUS

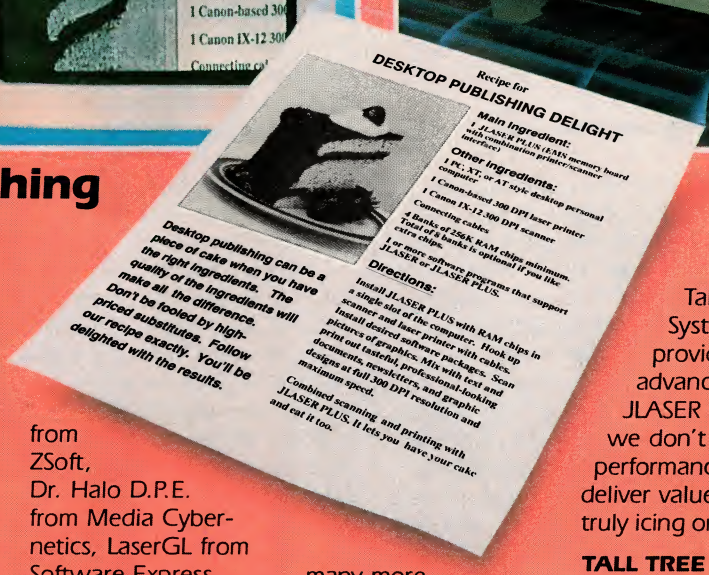
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Princeton Graphic Systems' Ultrasync color monitor



Microsoft Mouse with adapter for the IBM Personal System/2

The **TA/2** is an interface board that is used to attach Alloy's high-capacity Retriever/120 cartridge tape back-up unit to the PS/2. TS/2, $695; ResQNET, $100; HI/2, price not yet available; TA/2, $100; 40MB tape cartridge, $45.
Alloy Computer Products, Inc., 100 Pennsylvania Avenue, Framingham, MA 01701; 617/875-6100

CIRCLE 342 ON READER SERVICE CARD

A memory expansion board for use with the IBM Personal System/2 (PS/2) has been announced by **Orchid Technology**. The **RamQuest 50/60** is designed for the PS/2 Models 50 and 60 adds 2MB of RAM and supports expanded memory as well as the extended memory necessary for the upcoming Operating System/2 (OS/2). Software enhancements include a RAM disk (stores data in a virtual disk in fast RAM), print spooling (puts print data in a buffer), and disk caching (holds disk data in RAM for fast access). $995.
Orchid Technology, 45365 Northport Loop W, Fremont, CA 94538; 415/683-0300

CIRCLE 341 ON READER SERVICE CARD

A color monitor with automatic scan-range sensing capabilities is being offered by **Princeton Graphic Systems**. Available for the PC, PC/XT, PC/AT, Personal System/2 (PS/2), and the Apple Macintosh II, the **Ultrasync** features multifrequency horizontal- and vertical-scanning capabilities. The Ultrasync comes complete with cables, offers a 12-inch, 0.28mm-dot pitch CRT, and operates with either transistor-to-transistor logic (TTL) or analog inputs. This monitor can automatically synchronize with any horizontal scan frequency within the 15-KHz to 35-KHz range and, most notably, with any vertical frequency within 50-Hz to 12-Hz range. The Ultrasync supports an infinite color palette in analog mode. Ergonomically designed, it features a built-in, tilt-and-swivel base, small footprint, green/amber/white on blue text switch, and a black matrix non-glare screen.

Also introduced by Princeton is the **PSC-28**, a PS/2-compatible color monitor that is similar to the IBM 8513, but it has extended capabilities such as a built-in text switch.

Two monochrome monitors that are compatible with the PS/2 models also were announced. The **PSM-03** is a 12-inch white phosphor screen capable of displaying infinite shades of gray, and the **MAX-15** is a 15-inch white phosphor, multifrequency monitor. Ultrasync, $795; PSC-28, $695; PSM-03, $250; MAX-15, $280.
Princeton Graphic Systems, 601 Ewing Street, Building A, Princeton, NJ 08540; 800/221-1490; in New Jersey, 609/683-1660

CIRCLE 323 ON READER SERVICE CARD

A high-resolution graphics board compatible with the Video Graphics Array (VGA) standard is available from **Sigma Designs, Inc.** Designed for the PC, PC/XT, PC/AT and compatibles, the **SigmaVGA** provides the same level of function and capability as the integrated VGA graphics on IBM Personal System/2 (PS/2). In addition to emulating IBM monochrome, CGA, and EGA modes, the SigmaVGA also supports 320-by-200-pixel resolution in 256 colors or 64 gray scales, 720-by-400 in 16 colors or graph scales for high-resolution text, and 640-by-480 in 16 colors for all-points-addressable (APA) text and graphics. The SigmaVGA has 256KB of onboard memory and incorporates the same digital to analog converter used by IBM, offering up to 256 colors selected from a palette of 256,000. The adapter interfaces with the PS/2 monitors and all compatible monitors. $579.
Sigma Designs, Inc., 46501 Landing Parkway, Fremont, CA 94538; 415/770-0100

CIRCLE 328 ON READER SERVICE CARD

Microsoft Corporation has designed a version of its mouse that is compatible with the IBM Personal System/2 (PS/2) and connects directly to the pointing-device port. The driver for the **Microsoft Mouse IBM PS/2 Version** also supports the advanced video capabilities of the PS/2: Multicolor Graphics Array (MCGA), which is a superset of IBM CGA, on the Model 30; and Video Graphics Array (VGA), which is a superset of IBM EGA, on Models 50, 60, and 80. In addition, the mouse driver supports all of the PS/2 modes and comes with upgraded versions of Show Partner and Microsoft Paintbrush to take advantage of the video capabilities of the PS/2 models. $175.
Microsoft Corporation, 16011 NE 36th Way, P.O. Box 97017, Redmond, WA 98073-9717; 800/426-9400; in Washington and Alaska, 206/882-8080

CIRCLE 325 ON READER SERVICE CARD

A series of enhancement products for the IBM Personal System/2 (PS/2) has been announced by **AST Research, Inc.** Initially, the company has introduced two products: the **Rampage/2** expanded memory board for the IBM Model 30 and the **Advantage/2** multifunction board for IBM Models 50 and



AST's Advantage/2 multifunction board for the PS/2

60. A switchless board for easy installation, the Rampage/2 offers users of the IBM Model 30 a minimum configuration of 64KB of added memory (which is expandable to 2MB). Rampage/2 supports standard Lotus/Intel/Microsoft expanded memory specification (EMS) applications as well as AST/Quadram/Ashton-Tate's enhanced EMS (EEMS)

On April 2, 1987 IBM and Quarterdeck announced the next generation in personal computing.

Introducing DESQview 2.0. Improving the past and ready for the future right now.

In one sweeping announcement from Miami Beach and New York City, IBM established new standards of performance for personal computers, with its new Personal System/2.™ Quarterdeck was there with IBM and simultaneously helped establish new standards for multi-tasking and multi-windowing.

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If you use two or more software programs, if you use a PC-compatible machine, if you own a new 80386 computer, if you've just bought one of the new Personal System/2 computers, or if you've tried Microsoft Windows and were disappointed but still need the power of graphics programs, DESQview 2.0 is the answer.

Consider this. InfoWorld voted DESQview's earlier version 1986 Product of the Year. SoftSector gave it the Editor's Choice Award. In PC Tech Journal's "System Builder Contest" at Comdex Fall it was voted best operating environment. And 450,000 dedicated users on four continents have voted yes with their dollars.

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No. of Copies	Media 3½"/5¼"	Product	Retail Price ea.	Total
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		Shipping & Handling USA	$ 5.00	$
		Outside USA	$ 10.00	
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Mail to: Quarterdeck Office Systems, 150 Pico Boulevard, Santa Monica, CA 90405

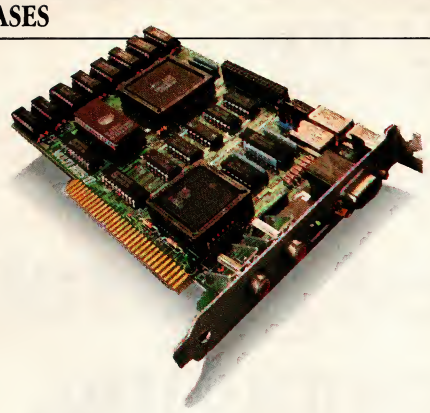
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CIRCLE NO. 137 ON READER SERVICE CARD



Multi Res II EGA-compatible adapter from STB Systems, Inc.



Ansa Software's Paradox 2.0 database-management system

applications. AST's SuperPak utility software, included with the board, supports print spooling and the creation of RAM disks. The Advantage/2 multifunction expansion board takes advantage of the PS/2 Micro Channel, providing added memory and optional I/O capabilities on one card. Using 256KB and 1Mbit chips, Advantage/2 can provide more than 2MB of extended memory, with a minimum configuration of 512KB. Prices for Rampage/2 range from $345 for 64KB to $1,145 for 2MB; Advantage/2 prices range from $495 for 512KB to $995 for 2MB.
AST Research, Inc., 2121 Alton Avenue, Irvine, CA 92714-4992; 714/863-1333
CIRCLE 326 ON READER SERVICE CARD

A high-resolution gaphics adapter for the IBM Personal System/2 has been introduced by **STB Systems, Inc.** The **VGA Extra** supports the Video Graphics Array (VGA) and provides compatibility with other video standards—IBM EGA, CGA, monochrome display, and the Hercules Graphics Card. The adapter supports 640-by-480-pixel resolution, 2- and 16-color IBM VGA modes. The STB product maintains VGA compatibility through hardware support at the BIOS level.

Also offering VGA compatibility, STB's **Multi Res II** produces standard video resolutions of 640 by 350, 640 by 480, and 752 by 410 pixels; on multifrequency monitors, the adapter also displays a 704-by-519, square-pixel resolution. A 132-column capability in color or monochrome is provided for spreadsheet and terminal emulation packages. For running 640-by-350 EGA color software on standard monochrome monitors, the adapter automatically converts colors to 16 shades and offers 1,056-by-352-pixel resolution for displaying Microsoft Windows on monochrome monitors. The ROM BIOS chip will be made available for upgrading the current EGA Multi Res board to VGA compatibility. VGA Extra, $495; Multi Res II, $349.
STB Systems, Inc., 1651 N. Glenville, Suite 210, Richardson, TX 75081; 214/234-8750
CIRCLE 327 ON READER SERVICE CARD

TECHNOLOGY

The **Personal Computer Enhancement Operation (PCEO)** of **Intel Corporation** has announced the availability of Intel's high-performance, 32-bit **80387 Math Coprocessor**. The 80387 has a clock speed of 16-MHz and operates in PCs based on Intel's 80386 or the PC/AT using the InBoard 386, Intel's 80386 add-in board. The 80387 has been optimized for the 80386 to provide the highest possible floating-point performance and directly extends the 80386 instruction set to include trigonometric, logarithmic, exponential, and arithmetic instructions. $795.
Intel Corporation, Mail Stop CO3-07, 5200 N.E. Elam Young Parkway, Hillsboro, OR 97124-6497; 800/538-3373; in Oregon, 503/629-7354
CIRCLE 308 ON READER SERVICE CARD

DATABASE MANAGEMENT

A true multiuser, database-management package is available from **Ansa Software**. Working on major networks (including 3Com's 3Plus, Novell's Advanced Netware, IBM Token-Ring, IBM PC Network, AT&T's StarLAN, and Torus Tapestry), **Paradox version 2.0** allows unlimited, simultaneous access to all records for transparent data sharing. Multiuser features include automatic refresh, which updates information to the screen as it is revised by other users; automatic table- and record-locking to insure data integrity; and deadly embrace protection, a feature that prevents crashing when more that one user seeks access to the same information at the same time. Paradox 2.0 also includes an enhanced edition of the Paradox Personal Programmer, an application generator that allows developers to set up complex data-management applications by making selections from menus. Additional features are support of expanded-memory protocols, increased record capacity from 64,000 per file to more than 2 billion. The **Network Pack** supports a maximum of six users on a LAN. Paradox 2.0, $725; upgrade to version 2.0 for purchases made between April 18 and May 18, 1987 is free; upgrade for purchases made after May 18 and before July 1, 1987, $139; upgrade after July 1, 1987, $199; runtime license per 250 copies, $9.95; Network Pack, $995.
Ansa Software, 1301 Shoreway Road, Belmont, CA 94002; 415/595-4469
CIRCLE 330 ON READER SERVICE CARD

Data Language Corporation (DLC) has shipped **LAN PROGRESS**, a PC LAN database server version of PROGRESS, a fourth-generation language and transaction-processing, relational database management system. LAN PROGRESS runs on LANs that provide IBM-compatible NETBIOS communication services, such as Novell's Advanced Netware, IBM Token-Ring Network and PC Network, Exelan, and EXOS. LAN PROGRESS offers automatic crash detection and recovery to provide fault-tolerant data processing on NETBIOS-compatible LANs. Any hardware or software failure that occurs (either on the database server or on a LAN-user node), is detected by the system. If any partial transactions were in process when the failure occurred, they are backed out of the database without user intervention. $2,450.
Data Language Corporation, 47 Manning Road, Billerica, MA 01821; 617/663-5000
CIRCLE 332 ON READER SERVICE CARD



PC MAGAZINE EDITOR'S CHOICE

*. . . one package stands out as the best support available for Turbo Pascal programmers: **Blaise Computing's Turbo Power Tools.** This definitive set of prewritten Pascal functions and procedures will make the life of any programmer—from the beginner to the hard-core professional—easier and more productive.*

Power Tools Plus™

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NO SECRETS

Turbo POWER TOOLS PLUS is crafted so that the source is efficient, readable and easy to modify. We don't keep secrets! We tell you exactly how windows are managed, how interrupt service routines can be written in Turbo Pascal, and how to write memory resident programs that can even access the disk. Maybe you've heard of some undocumented DOS features that resident programs use to weave their magic. Turbo POWER TOOLS PLUS documents these features and lets you make your own magic!

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- **INTERRUPT SERVICE ROUTINES** that can be written in Turbo Pascal without the need for assembly language or inline code.
- **INTERVENTION CODE** lets you develop memory resident applications that can take full advantage of DOS capabilities. With simple procedure calls, you can "schedule" a Turbo Pascal procedure to execute either when a "hot key" is pressed, or at a specified time.
- **PROGRAM CONTROL ROUTINES** allow you to run other programs from Turbo Pascal, and even execute DOS commands.
- **MEMORY MANAGEMENT** allows you to monitor, allocate and free DOS-controlled memory.
- **DIRECTORY AND FILE HANDLING** support to let you take advantage of the newer features of DOS including networking.
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- **FULL SOURCE CODE** for all included routines, sample programs and utilities.
- **DOCUMENTATION, TECHNICAL SUPPORT** and attention to detail that have distinguished Blaise Computing over the years.

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The underlying functions of Turbo ASYNCH PLUS are carefully crafted in assembler for efficiency and drive the UART and programmable interrupt controller chips directly. These functions, installed as a runtime resident system, require just 3.2K bytes. The high level function are all written in Turbo Pascal in the same style and format as Turbo POWER TOOLS PLUS. All source code is included for just $99.95.

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Javelin PLUS financial-analysis package from Javelin Software



Universal Technical Systems, Inc's TK Solver Plus

Expanding on the strengths of the original Javelin design, **Javelin PLUS**, a financial-analysis package that combines spreadsheet/modeling and database functions has been released **Javelin Software Corporation**. Features of Javelin PLUS consist of a central information base surrounded by views or ways of entering, manipulating and reporting data. Javelin PLUS, as an analysis tool, represents numbers and their relationships logically, automatically self-documenting the user's work, and thus ensuring the integrity of his data. Javelin PLUS's database functions allow the user to select or sort records in a list as part of the model. Cross-tabulation functions allow summarization of database information over time. An open architecture design allows unlimited application-specific additions to Javelin PLUS. Four snap-in modules are included: What If, Forms Input, Multiple Regression, and Histogram; more are planned. A developer's Snap-In Building-Block kit, a Forms Entry Snap-In Building Block, a range restrict feature, and a /File Run command for incorporating DOS commands are some of the system builder features. $249, upgrades prior to September 1, 1987, $79; afterward, $150.
Javelin Software Corporation, One Kendall Square, Building 200, Cambridge, MA 02139; 617/494-1400
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SOFTWARE DEVELOPMENT

An enhanced version is available of **Visible Systems Corporation**'s computer-aided software engineering (CASE) productivity tools. **Release 2.2** of the **Visible Analyst Workbench** consists of three modules: the **Visible Analyst**, the **Visible Rules**, and the **Visible Dictionary**. The Visible Analyst is a computer-aided software engineering tool for creating and editing software engineering diagrams of all kinds. It can handle all of the leading structured methodologies and is distinguished by its diagramming and editing versatility. Some major features are Quickdraw, which enables the user to redraw a diagram in an average of 5 seconds; a custom symbol generator that draws from a library of up to 40 symbols that can be created, copied, edited, or replaced; and flexible text and lines, which gives the user the ability to use a variety of line styles and text fonts. The Visible Analyst contains on-line context sensitive help. The Visible Rules contains expert rules used for design validation to ensure consistency and completeness. The Visible Dictionary is a central definition catalog with key project-related information to ensure uniformity of expression. The Visible Analyst, $595; the Visible Analyst Rules (Visible Analyst and Visible Rules), $1,190; the Visible Analyst Workbench (Visible Analyst, Visible Rules, and Visible Dictionary), $1,785.
Visible Systems Corporation, 49 Lexington Street, Newton, MA 02165; 617/369-1800
CIRCLE 338 ON READER SERVICE CARD



Screen shot of Visible Systems' Visible Analyst Workbench

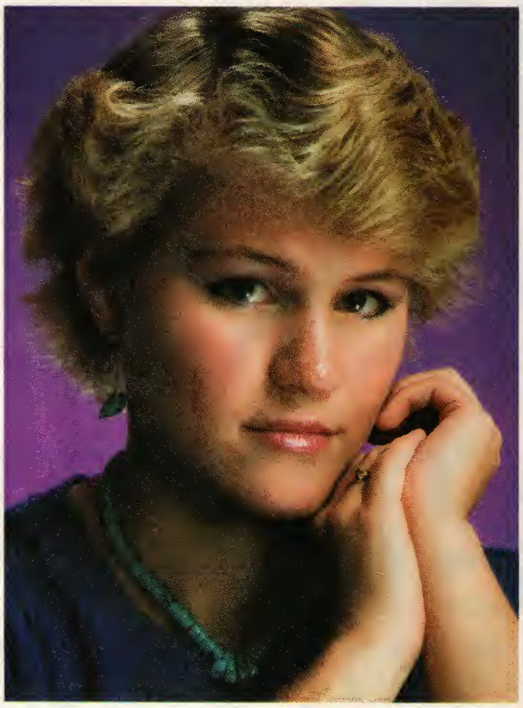
An enhanced edition of TK!Solver, **Universal Technical Systems, Inc.**'s algebraic equation processing product, has been shipped. **TK Solver Plus** features high-resolution graphics, supports the 8087 or 80287, reads and writes .WKS/.WK1 format files, offers easy-to-use tables for input and output, adds complex number arithmetic, and supports user-defined procedure functions. A library of models, pull-down menus and context-sensitive help is included. It can solve one or more linear or nonlinear equations simultaneously, via either direct algebraic solution or iteration. User-defined procedure functions extend TK!Solver's more than 70 built-in functions. It can solve equations with complex numbers, allow numerical interpretation of relational operations, and uses Boolean variables and functions for logical or conditional computation. $395; trial pack, $25.
Universal Technical Systems, Inc., 1220 Rock Street, Rockford, IL 61101; 800/435-7887; in Illinois, 815/963-2220
CIRCLE 337 ON READER SERVICE CARD

A shell programming language has been developed by **Gryphon Microproducts**. The **Weiner Shell** language generates memory-resident programs that can run in the background. Programmers easily can apply the Shell language to existing software. The Weiner Shell can take advantage of as much as 8MB of available expanded memory; any program run with the Shell can also access that memory. Other features include DOS interrupt capability, user I/O, user-defined keys, array- and queue-processing, taking a snapshot and playing back a maximum of 250 screens, floating-point arithmetic, and file selection by date, time, and content. $199.
Gryphon Microproducts, P.O. Box 4104, Silver Spring, MD 20904; 301/384-6868
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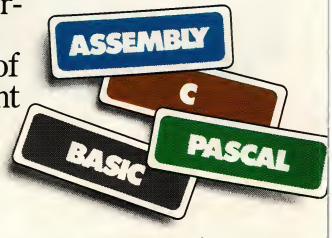
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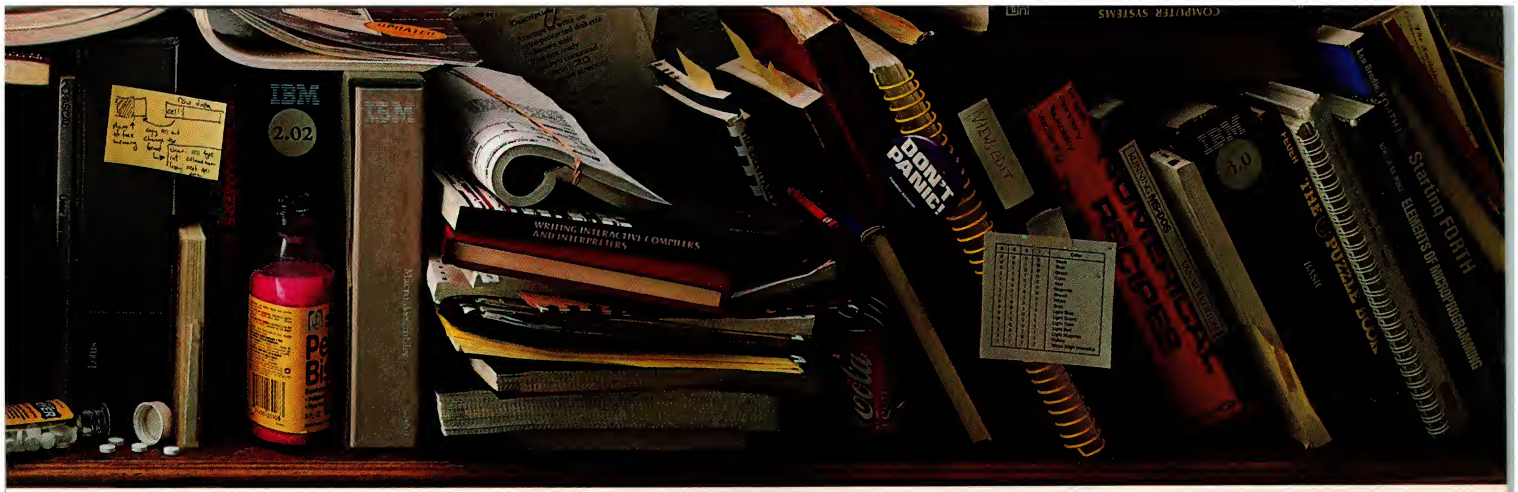


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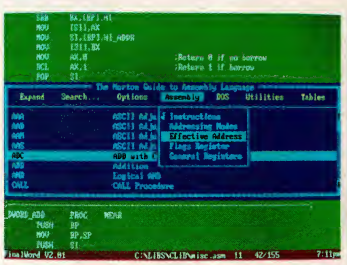
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THE PROGRAMMER'S SHOP

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TP2C - Translate Turbo Pascal to formatted K & R C (proposed ANSI 85 standard). Include files, in-line code, nested procedures. 95 + % successful conversion. PC $ 219

AI-Expert System Dev't

Arity Combination Package	PC	$ 979
System - use with C	MS	$ 229
SQL Dev't Package	MS	$ 229
Auto-Intelligence	PC	$ 739
Experteach - Powerful, samples	PC	$ 339
Exsys	PC	$ 309
Runtime System	PC	$ 469
Insight 2+	MS	$ 379
Intelligence/Compiler	PC	$ 739
T.I. - PC Easy	PC	$ 435
Personal Consultant Plus	PC	$2589
Personal Consultant Runtime	PC	$ 85
Turbo Expert-Startup-(400 rules)	PC	$ 129
Corporate (4000 rules)	PC	$ 359

AI-Lisp

Microsoft MuLisp 85	MS	$ 159
PC Scheme LISP - by TI	PC	$ 85
TransLISP - learn fast	MS	$ 89
TransLISP PLUS		
Optional Unlimited Runtime		$ 139
PLUS for MSDOS		$ 179

Others: IQ LISP ($155), IQC LISP ($269)

AI Prolog

APT - **A**ctive **P**rolog **T**utor - build applications interactively	PC	$ 49
ARITY Prolog - Interpreter	PC	$ 229
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CIRCLE NO. 162 ON READER SERVICE CARD

TED FORGERON

Which Math Coprocessor?

For maximum performance, a program identifies the math coprocessor (the 8087, 80287, or 80387) functioning in a system.

Although Intel's 8087, 80287, and 80387 Numeric Data Processors (NDPs) are similar, they have a few significant differences that programmers can use to squeeze that last ounce of performance from their numeric applications. To take advantage of these differences, a program must be able to detect, at runtime, which math coprocessor is installed.

The NDPTYPE program (listing 1) includes the Intel-recommended techniques for detecting and identifying the coprocessor. Although other algorithms may detect the difference, they cannot be guaranteed to perform correctly with future math coprocessors from Intel.

An instruction in the NDPTYPE program, called FNSTCW (store control word, no wait), determines the presence of a coprocessor. (For a description of this process, see "Machine Specifics," Ted Forgeron, June 1985, p. 181.)

One distinguishing feature of the 8087 is its response to the FENI (enable interrupts) and FDISI (disable interrupts) instructions. Both instructions set the interrupt behavior of an 8087, but are ignored by the 80287 and 80387. NDPTYPE sends an FDISI instruction to the NDP; if this turns off the interrupt bit in the NDP control word, then it is an 8087.

To distinguish between the 80287 and 80387, NDPTYPE tests the default infinity mode. The two infinity modes possible on Intel math coprocessors are *affine* and *projective*. The 80387 defaults to the affine mode and both the 8087 and 80287 default to the projective mode.

In the affine mode, positive and negative infinities are two distinct values; the domain of real numbers is represented by a line extending infinitely in either direction. In the projective mode, infinity is only one value, neither positive nor negative; the real number line is closed into a circle of infinite circumference.

NDPTYPE generates both positive and negative infinities by dividing by zero; if the two infinity values compare equal, the coprocessor has defaulted to the projective mode and the math coprocessor is an 8087 or 80287. If the two values are different, the coprocessor has defaulted to the affine mode and, therefore, is an 80387.

Although the main purpose of NDPTYPE is to demonstrate testing procedures for incorporation into other programs, it can be used as a stand-alone program. The user can assemble NDPTYPE with the Microsoft Macro Assembler 4.0, link it with any compatible DOS linker, and convert it to a .COM file with EXE2BIN. The assembler's /R switch must be enabled for the assembler to recognize the math coprocessor instructions. Without /R engaged, the assembler generates a syntax error for the coprocessor instructions.

Ted Forgeron is an engineering program manager for Intel Corporation. He is also coauthor of the Programmer's Reference Manual for IBM Personal Computers *(Dow-Jones Irwin, 1987) and a contributing editor to* PC Tech Journal.

LISTING 1: NDPTYPE.ASM

```
; NDPTYPE -- Check for math coprocessor presence and type
code    segment public
assume cs:code,ds:code
        org     100h                    ;set up as a COM file
start:  jmp     begin
control dw      0
msg_no  db      'No math coprocessor present $'
msg_87  db      '8087 math coprocessor present $'
msg_287 db      '80287 math coprocessor present $'
msg_387 db      '80387 math coprocessor present $'

;---------------------------------------  TEST FOR PRESENCE OF NDP
begin:  mov     dx,offset msg_no        ;load not-present message
        fninit                          ;initialize math coprocessor
        mov     byte ptr control+1,0    ;clear memory byte
        fnstcw  control                 ;store control wrd in memory
        mov     ah,byte ptr control+1   ;upper byte is 03h if
        cmp     ah,03h                  ;  coprocessor is present
        jne     print                   ;no math coprocessor

;---------------------------------------  CHECK IF 8087
chk87:  mov     dx,offset msg_87        ;load 8087 message
        and     control,NOT 0080h       ;turn interrupts on (IEM=0)
        fldcw   control                 ;load control word
        fdisi                           ;disable interrupts (IEM=1)
        fstcw   control                 ;store control word
        test    control,0080h           ;if IEM=1, then 8087
        jnz     print                   ;display 8087 message

;---------------------------------------  CHECK IF 80287 OR 80387
chk287: mov     dx,offset msg_287       ;load 287 message
        finit                           ;use default infinity mode
        fld1                            ;generate infinity
        fldz                            ;  by dividing 1 by zero
        fdiv                            ;
        fld     st                      ;form negative infinity
        fcom                            ;
        fstsw   control                 ;compare +/- infinity
        fwait                           ;equal for 87/287
        mov     ax,control              ;wait for fstsw to complete
        sahf                            ;get NDP control word
        jz      print                   ;stor condition bits in flags
                                        ;jt's 287 if infinities equal

;---------------------------------------  IT IS AN 80387
is387:  mov     dx,offset msg_387       ;otherwise, it's a 387
print:  mov     ah,09h                  ;dos print string function
        int     21h                     ;call dos
        mov     ax,4c00h                ;dos terminate program
        int     21h                     ;call dos
code    ends                            ;
        end     start                   ;start is the entry point
```



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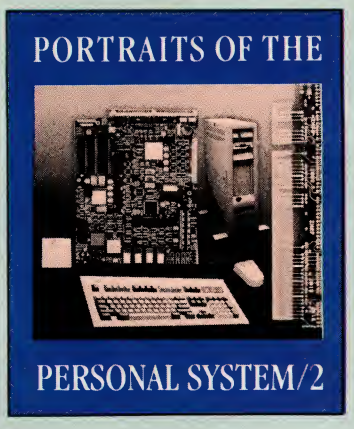
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What IBM Did Right and Wrong

Part/2

Piece by piece we paint a portrait of the PS/2, rating each part as we go. We can say now that IBM was not all thumbs on this one.

WILL FASTIE

This is a portrait that begins with thumbs—some up, some down. It is a portrait that fills out this entire issue of *PC Tech Journal*, including as it does a technical analysis of all the new components of IBM's much heralded Personal System/2: architecture, graphics capabilities, individual models, market context, performance, operating systems, 3270 communications, and local area network concerns.

The PS/2 family is complex, from both technical and marketing perspectives. IBM has proffered several significant technical advances: the new Micro Channel Architecture, designed to improve reliability and support future growth; the Video Graphics Array (VGA), an extended EGA built into the PS/2 machines; and improved reliability through reduced circuitry, better manufacturing methods, and surface-mount technology. Of future import is Operating System/2 (OS/2), including the Presentation Manager (a Microsoft Windows-derived graphical user interface). IBM marketers can vaunt the smaller footprint, new styling, standard features, disk-caching performance, and numerous other amenities that complete the PS/2 portrait.

Our editorial staff worked as a team to understand and define PS/2. *PC Tech Journal*'s portrait of the new family on the following pages represents the best of a group of people truly excited by advances in the field of personal computing and dedicated to technically accurate, careful analysis. But first, an explanation of the thumbs.

In the premier issue of *PC Tech Journal* in the summer of 1983 I had the courage (or perhaps the audacity) to pass judgment on what IBM did right and wrong in designing the PC. Using thumbs as my unit of measure, I gave IBM a lukewarm thumbs-up rating. Now here it is four years later, and IBM has introduced the Personal System/2 family of computers. How can I shirk my responsibility to do the same for the PS/2 models?

Therefore, I turn my attention to IBM's newest machines, praising or panning the PS/2's key elements as appropriate—addressing, one by one, the PS/2 hardware, operating systems, connectivity, compatibility, and performance. A thumbs-up or thumbs-down icon at the beginning of each section signifies favor or disfavor with the issue at hand (no pun intended). And just to save everyone the trouble of counting, I can tell you in advance that, overall, the PS/2 family earns a thumbs-up rating from *PC Tech Journal*.

IBM's new offerings should be viewed as a family and not just a set of individual, desktop computers. The family connection is critical to IBM and is at the heart of its current advertising campaign in which the M*A*S*H "family" touts the PS/2 family.

The following comments, therefore, deal with issues pertaining to the entire family and touch upon the sometimes thorny relationships between the individual family members.



ILLUSTRATION • JANE STERRETT

THE FAMILY NAME



When IBM chose the *Personal Computer* moniker for the first generation of its desktop computers, it may have had no idea the nickname *PC* would come to symbolize not just IBM products but, in effect, a whole industry. Because those two initials stuck so hard and fast, IBM faced quite a dilemma when the time came to name the new generation.

Selecting a name was strictly a marketing question. IBM knew it had to provide a good solution for its most important customer base, the owners of its mainframe and midrange computers. The new computers had to fit in with that line of products: the *System*/370, the *System*/38, and the *System*/36. At the same time, IBM could hardly announce a new set of desktop machines without appealing to the constituency that made the *personal* computer so wildly successful.

How could the marketers miss with a name like Personal System/2? It looks and sounds enough like personal computer to appease the PC crowd, but has the ring of the more substantial IBM systems. It even has the slash, a sure indicator that the new family represents a mainstream IBM architecture.

LOOK AND FEEL



Overnight IBM has outdated the styling of the current PC family. The PC/AT that only yesterday looked so powerful and impressive on your desk now looks huge and awkward. By providing new, attractive packaging for the PS/2 computers and making the larger models floor-standing units, IBM has brought a new standard of convenience and style to the industry. In the process it has reduced system size and weight, heat and noise, and power consumption. Equally appealing is the ease with which these systems can be set up, disassembled, and maintained.

DIMENSIONS



The new desktop systems are too deep to fit comfortably on a standard 24-inch-deep work surface. This is not a new problem, nor is it a serious defect, but it is one that will provide widespread inconvenience. IBM should have paid at least as much attention to making the PS/2s shallow enough to fit on commonly available work surfaces as it did to making the machines narrower.

THE KEYBOARD



Every time IBM has announced a new computer, the first complaints voiced are about the keyboard. This time IBM earns a hearty thumbs-up because it did *not* change the keyboard layout (see photo 1). It is the same 101-key enhanced version announced with the RT PC and, shortly thereafter, with the AT 339 and XT 286 (see "Keying on a Standard," Bob Smith, July 1987, p. 134). That simply means that IBM, understanding its vulnerability, preannounced the keyboard to avoid subjecting its new family to abuse.

IBM promises that this will be its universal keyboard, appearing on the desktop family line as well as on other IBM products. That should make the large mainframe customers very happy.

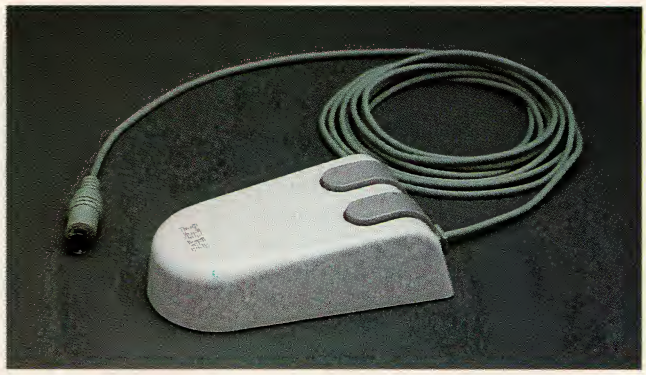
On this now-standard keyboard, the Esc key is in the correct (or at least a good) spot; the function keys, which run along the top of the keyboard, are 12 in number (a 3270 issue); NumLock, CapsLock, and ScrollLock have light indicators; and a set of cursor keys floats alone, allowing full use of the numeric keypad. There is even a pencil ledge, although it will more often be

PHOTO 1: *Enhanced Keyboard*



It's the same! For once, IBM announced a new computer and did not change the layout of the keyboard.

PHOTO 2: *IBM PS/2 Mouse*



IBM now offers its very own mouse, manufactured by Alps America, that connects directly to the PS/2 mouse port.

used to support key templates. These are all good features.

The one negative factor is teaching your fingers the layout, after having used the PC-style arrangement for so long. This is worsened by the fact that many software vendors have tried to place functions on keys in a useful and meaningful way. For example, the indent key in WordPerfect is F4, just to the left of its first cousin, the Tab key. On the Enhanced keyboard, the logic for its position disappears.

BUILT-IN VGA

The Video Graphics Array (VGA), IBM's new display standard, elicits mixed emotions. Look a little further down the page for the thumbs-down treatment.

What is great about the VGA is that it is built into every PS/2, except the Model 30 (which, as you will discover by reading on, I do not consider to be a true member of the family). This eliminates quite a bit of decision-making—no more agonizing choices between text and graphics.

The buying decision is reduced to choosing among monitors of varying features and prices. Better yet, each of the four PS/2 monitors works on any PS/2. Building in the basic display hardware was definitely the right move.

CONSERVATIVE VGA

Unfortunately, the VGA is less than we might have hoped for. It is merely IBM's own EGA clone—in some sense, it can be considered a "fixed" EGA.

IBM was too conservative in creating the VGA's feature set. Many of the features, like the 640-by-480, 16-color mode, are available on upscale (although not expensive) third-party EGA-compatible boards. In fact, the VGA's limitation to 16 colors in 640-by-480 mode is a serious flaw. The imaging capabilities of the 320-by-200, 256-color mode, even available on the Model 30, are excellent; just imagine the possibilities at twice the resolution.

The design is not directly expandable, however, so adding display memory does not bring more color or higher resolutions. With a more flexible basic design, higher resolutions, faster processing, or built-in primitives could have been achieved simply by adding more memory or processing power on top of the supplied circuitry.

In graphics, we always seem to want more than we get. One reason for that is the creativity of the aftermarket, which quickly responds to fill in the gaping holes. IBM should have supplied greater capability in every machine so that the aftermarket, instead of supplying basic hardware, could have concentrated on expansion options.

This is precisely what happened in the aftermarket for the Apple Macintosh. It is the graphics capability of the Mac II that makes everyone drool. IBM should have given us a little bit more.

SOPHISTICATED BUS

From a hardware point of view, the Micro Channel Architecture is the most significant technological advance in the PS/2 family. It is a fully defined bus architecture that allows adherence to defined rules rather than determining bus behavior through experimentation. It gives not only the machines, but also the entire architecture of the machines, a long life span. It is also an important enabling technology, one that creates a vast new opportunity and provides a big step toward multitasking support.

This kind of sophisticated, minicomputer-like bus is essential for more demanding applications, such as transaction processing, multiprocessing, or fault-tolerant computing. For the average, everyday user, the bus lessens the chance of a glitch. Either way, the Micro Channel is a good and proper step forward, and it is the single element that makes a machine qualify as a blood relative of the PS/2 family.

PORT CONTROL

IBM took long enough, considering that Compaq and other compatible manufacturers have done it all along, but the system board (which IBM insists on calling the *planar board*) now contains many of the fundamental requirements for all desktop computers. Included are base system memory, one serial port, one parallel port, a clock, and, of all things, a mouse, or "pointing-device," port. (IBM now offers its own mouse to connect to the PS/2 mouse port, as shown in photo 2). Not included on the system board, and correctly so, are the system switches.

This is just the right combination. All ATs used at *PC Tech Journal*, for example, are equipped with expansion memory, two serial ports (one for a modem and one for a mouse) and the parallel port; aside from the parallel and first serial ports, these are extra-cost options. Our configurations are typical (based on our reader research), so we expect many others have had similar frustrations about this set of "required" options.

MEMORY SUPPORT

On the other hand, IBM is playing games with us regarding the basic memory configuration of these machines. Each PS/2 (except the non-PS/2 Model 30) comes with 1MB of memory, so filling

out 640KB is no longer an issue. However, not many users are satisfied with 1MB, as evidenced by the brisk sales of expanded memory boards. Furthermore, IBM's new OS/2 is expected to be quite demanding of memory, requiring a minimum of 1.5MB of base and extended memory for a usable OS/2 configuration, 2MB for DOS environment support, and 3MB to run OS/2 Extended Edition.

The PS/2 family follows the questionable lead of the PC family by delivering a minimal amount of memory on the system board but offering no room for expansion there. This is in sharp contrast to the Macintosh SE, for example, which comes with 1MB onboard memory that can be upgraded to 4MB by replacing the single in-line memory modules (SIMMs) with higher density RAM. IBM's offering of an expanded memory board does not appease; IBM memory is typically small and expensive. Competitors offer four times the memory in the same space as IBM and at much better prices.

This is not a problem for the moment because DOS cannot exploit extended memory anyway. Nonetheless, AST already has announced the Advantage/2 extended memory board for Models 50 and 60, and Intel is reportedly working on similar products. Expect other vendors to do the same. These third-party products at least will let our favorite applications and utilities play with a lot of affordable memory until OS/2 can fully exploit it.

THE NON-PS/2 MODEL 30



From a marketing point of view, IBM wants to present its customers with a unified family of computers. It is stretching the family ties a bit, however, with the Model 30 (And it is totally out in left field to proclaim, as the early advertising did, that the PC Convertible is a member of the family, too.)

The Model 30 is a PS/2 in name only. It does not have the VGA, the Micro Channel, an 80286 or 80386 processor, or a high-density diskette drive. It does not come with disk caching. Most importantly, it cannot run OS/2.

In fact, the only similarity between the Model 30 and other members of the PS/2 family is appearance. Its case has the same styling, and it drives the same analog monitors. Its diskette drive is 3.5 inches, but even that is a lower-capacity model. These comments apply equally to the PC Convertible.

IBM can declare that the Model 30 is part of the PS/2 family. But, by simple definition, it is not, and IBM is misleading us by claiming otherwise.

THE MODEL 30 (AKA XT/2)



As a replacement for the aging XT, however, the Model 30 is quite suitable. It is smaller and faster; the 8086 processor's clock rate is 67-percent faster; memory access is via a 16-bit bus (two bytes for the price of one) and requires no wait states; the hard disk, without caching support, is about 20-percent faster. Overall, IBM claims twice the performance of an XT for the Model 30. Our testing indicates that this is a reasonable estimate.

The Model 30 is no clone-basher, but it is an attractive low-end machine.

The Model 30 is a PS/2 in name only. It does not have the VGA, the Micro Channel Architecture, or an 80286 or 80386 processor.

It is priced at least $1,500 less than the Model 50 and $600 less than a similarly equipped XT. That is roughly twice the performance of an XT and much better graphics for 17-percent less. In addition to price, the Model 30 should interest small businesses with routine requirements because it is compatible at the bus level with the original PC family (and therefore with all the add-in board products). A diskette-only version may be attractive to the educational market (assuming heavy educational discounts), but probably still costs too much for home use. Perhaps a forthcoming Model 20 or Model 10 will address the home market.

Considered on its own, the Model 30 is a relatively nice machine.

MODEL 50 POSITIONING



If IBM felt the need to offer a machine that would compete directly with the new Macintosh SE, then the Model 50 is surely it. A similarly configured Model 50 is only $240 more than the Mac SE, but the Model 50 has three expansion slots and optional color, neither of which is an option on the Mac.

The Model 50 also compares favorably with its PC predecessors. Priced only $100 more than the XT 286 (configured comparably to a Model 50 with color monitor), the Model 50 offers a 10-MHz processor with one wait state to the XT 286's 6-MHz processor with zero wait states.

The AT 339, which has better raw disk performance than the Model 50, lists at close to $6,000 configured, almost 40-percent more than the Model 50. IBM-supplied disk-caching software brings the performance of the Model 50 up to the level of the AT 339—but still at the much lower price.

Best of all, the Model 50 is a full-fledged member of the PS/2 family, with Micro Channel, VGA, and a reduced desktop footprint. This means that the Model 50 is strategically positioned in the PS/2 line. Based on price and performance, IBM clearly intends for this machine to be a primary choice for all types of desktops and the primary replacement not only for the XT, but also for the XT 286, the AT 239, and even the AT 339.

Preliminary information from an informal poll of dealers confirms that the Model 50 is in high demand and is available, although on allocation. In other words, IBM hit the nail on the head with the Model 50 . . .

MODEL 50 HARD DISK



. . . Until you consider the hard disk, that is. A 20MB hard disk is not unreasonable for many desktops, but what is really irritating is that IBM did not offer a 40MB model as well; furthermore, the 20MB disk is *so* slow. The message IBM seems to be sending is that greater disk capacities require bigger machines, but that is nonsense. The underlying message is that IBM does not want this smaller machine to undercut sales of the Model 60, the machine that IBM probably views as the natural successor to the AT 339.

That's too bad. The Model 50 is a very desirable machine. IBM is penalizing users who need just a bit more hard-disk capacity and performance by forcing them upwards to a much more expensive machine. Worse, IBM gives no clear indication that the Model 50 will be a full-fledged member of the family when OS/2 rolls around; it advises potential users of OS/2 Extended Edition who anticipate large databases or many files to make sure their machines can be expanded beyond 20MB.

IBM has left a gaping hole here. Plus Development Corporation raced to fill a similar hole on the Model 30 with its 40MB Hardcard; I hope it can master the Micro Channel quickly and pro-

vide a more reasonable, useful solution for the Model 50 than has IBM.

MODEL 60 PERFORMANCE/COST



The Model 60 is the full-capability replacement for the AT 339; however, it does not offer significantly more performance or lower cost than the AT. In the current 286 market, a machine with 10-MHz processor, one-wait-state memory, noninterleaved disk, and cache software is not all that impressive, particularly at a cost of $5,295 with a 44MB disk and $6,295 with a 70MB disk. The AST Premium/286, which has a 10-MHz processor and zero-wait-state memory, provides higher performance and costs $3,495 with an EGA and 44MB disk or $3,995 with an EGA and 70MB disk. That is a lot of capacity and performance for a lot less money.

MODEL 80 PROGNOSIS



It is too early to criticize or praise the Model 80. *PC Tech Journal* was unable to obtain a machine to test in-depth in time for this issue, and the amount of time IBM graciously provided us on one of its units was, alas, insufficient for our degree of examination. However, based on what knowledge we gathered, IBM has set itself up for a fall on a machine that everyone has long been waiting for. The Model 80 may be *too* high-end and expensive. Compaq has a wonderful opportunity with both the Deskpro 386 and what I will call the Deskpro 386/2 (a PS/2 clone) to put IBM on the spot.

Again, IBM was too conservative. It should have announced, with quick availability, the Model 70, a desktop version of the Model 80 having the same relationship that the Model 50 has to the Model 60. This smaller configuration could provide cost-effective workstations with which customers could begin to explore 386 technology. With the prices of the Model 80 where they are, Compaq remains firmly in the 386 driver's seat.

IBM has no comment on the much-rumored Model 70; for once, though, it should break its rule of no future speculation and bring the Model 70, if there is one, quickly to market.

PATCHWORK DOS



IBM continues to struggle with operating systems. This time, it made some wrong moves and some right moves. The right ones are conceptual, however, and we will not see them for some time.

DOS 3.3 is the eighth release of the product, and it is beginning to show. DOS has become an amalgam of quick fixes and patches over a substrate that is not quite robust enough to handle all of the changes. As a result, enhancements seem less like the good ideas they should be and more like awkward solutions that are difficult to understand and use.

The biggest complaint that can be made about DOS is that the environment has not evolved very far. Although the casual user desires an easy, intuitive interface, the more sophisticated user, typified by *PC Tech Journal* readers, can handle the complexities of life on the command line. In fact, systems developers often do live at the C:> prompt, eschewing memory-wasting front ends such as Microsoft Windows or other DOS shells.

The Model 60 is the full-capability replacement for the AT 339; however, it does not offer significantly more performance or lower cost.

We have gotten short shrift. From revision to revision, only those enhancements absolutely needed have been supplied, and they have been grafted on without regard for DOS's architecture or the user's needs.

The command-line interface is especially annoying. Certain programmatic features have been added over time, such as the IF statement, but the additions have been the bare essentials. Batch files, which can be very useful for automating the critical tasks of backups and installations, are still incredibly convoluted and lacking in certain features. The command processor does not even allow the reading, storage, and later use of variable information from the keyboard; this would be a major enhancement of extraordinary value. It would not be difficult to add and would live in the transient portion of COMMAND.COM, taking up memory only for variable storage.

DOS 3.3 is, unfortunately, a trap. If you want to operate PS/2 machines safely, you must have this new, more expensive version of the operating system. Older versions of DOS can continue to run until a bug or a desired feature forces an update; at that time, DOS 3.3 will probably be the only version supported by IBM.

IBM may have realized that the real value of this version of DOS was limited, even though the price rose from $95 for version 3.2 to $120 for 3.3. For the first time, IBM included update and site pricing to reduce the cost impact of updates. That is certainly a positive step forward.

WAITING FOR OS/2



Let there be no question: IBM earns multiple thumbs-down for the long delay before OS/2 hits the market. The Standard Edition is not due until the first quarter of 1988, and we have to wait until the fourth quarter of 1987 even to find out the planned release date of the Extended Edition. It will take even longer for the applications to emerge that exploit the 286 processor and, much more importantly, the 386.

OS/2 is the operating system that should have been delivered with the AT in 1984. Only IBM and Microsoft know why they have taken so long to provide the operating system software that will exploit the power of the 286. We can take some solace in Microsoft's effort to help accelerate the progress of OS/2 software packages with its MS-OS/2 Software Development Kit. The toolkit, which is available now, includes a beta version of MS-OS/2. IBM has also announced an OS/2 Software Development Kit, but it will not be available until the initial release of OS/2 Standard Edition in 1988.

IBM talks about its growing dependence on software as a source of revenue, but the company's actions speak otherwise. Typical IBM thinking is that it is better to sell two 3090s than one with operating software that makes it twice as efficient. Look at the history of IBM's data management software as an example; third-party products usually offer higher performance.

OS/2 MULTITASKING

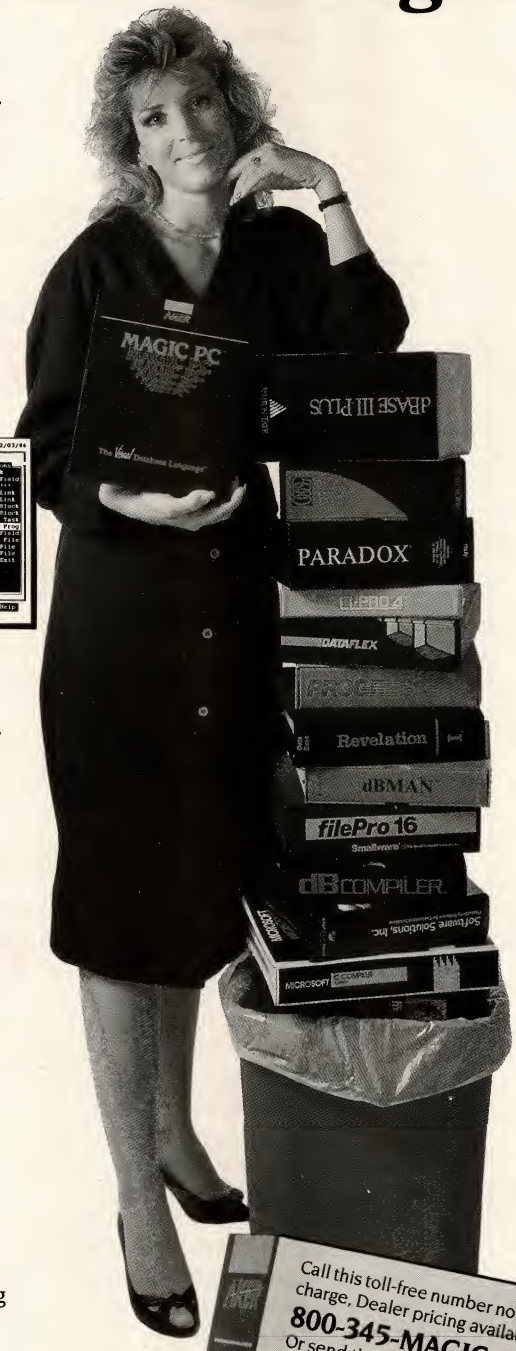


Although we will have to wait for it, OS/2 multitasking is bound to be a very important enabling technology.

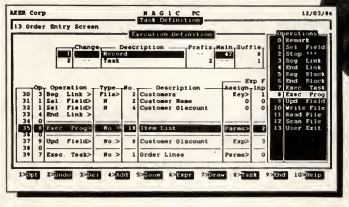
Before LANs and their servers can be truly effective, they need two capabilities: first, the nodes need to be able to run more than one program at the same time so that background tasks, especially those associated with communications, can operate concurrently; second, servers need to have an operating system that is the same as or sim-

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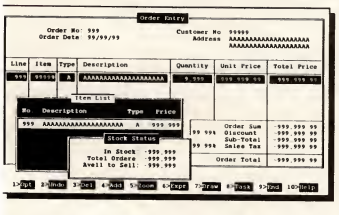


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ilar to the one at the nodes so that portions of applications, even those developed by the end-user company, can be placed directly on the server.

OS/2 and its multitasking features promise to meet these needs.

PRESENTATION MANAGER



At long last, Windows arrives wearing IBM colors and calling itself the Presentation Manager. IBM badly needed a standard graphical interface to give its desktop products the ability to compete with the Macintosh. If IBM had persisted with its orientation to text, Apple's momentum would have snowballed beyond even IBM's ability to curtail it.

IBM deserves credit for acknowledging the requirement and going with the vendor that was farthest along in development: Microsoft. Digital Research's GEM might have been the preferred environment because it resembles the Mac world more closely, but it does not yet appear to have underlying support for concurrent operation.

Whether the Presentation Manager as produced by Microsoft is the right choice is a question that cannot be answered until we know more about the final product. It is the concept that gets the nod of approval here.

3270 FOR THE MASSES



IBM did not exactly dazzle us with new connectivity announcements. Most attention was diverted by the announcement of OS/2 Extended Edition and its direct support for data management and communications, even though few details were available. Nonetheless, IBM improved its offerings in two areas: 3270 connections and LANs.

IBM has finally given up on the idea that a machine combining the characteristics of a personal computer and a 3270 terminal requires a separate hardware set. Everybody else already knew this, and the aftermarket created reasonable solutions by delivering a 3270 adapter board and software that could transform an ordinary PC into a 3270 PC.

IBM now conforms to the industry model. The 3270 PC Control Program runs on most PCs and all PS/2 models and is compatible with IBM's LANs. IBM offers 3270 adapter boards for PCs and PS/2s and even supplies its own expanded memory adapters for all its desktop machines instead of just for the 3270 PC models, as before.

All in all, this is one lesson IBM seems to have learned well.

LAN SUPPORT



IBM could have sorely disappointed by not having new LAN adapters ready when the new machines were announced, but it obviously foresaw the kiss of death and came prepared with Token-Ring adapters, PC Network adapters, and a LAN software update.

The primary interest in this area centers around the baseband version of PC Network, which now gives IBM a directly competitive product to AT&T's StarLAN. The baseband product is twice as fast as StarLAN and is IBM's least expensive offering for small network configurations, calculated on a per node basis with all elements included. Like StarLAN, it uses standard telephone wiring as its media.

IBM still has a long way to go before it can offer the simplicity and elegance of AppleTalk for entry-level networking, but the new network option is a small step in the right direction.

IBM would have been crazy to give up compatibility with almost 10 million PC-compatible machines installed. IBM is not crazy.

SOFTWARE COMPATIBILITY



The press had a field day on the subject of compatibility for at least a year prior to the announcement of PS/2. *PC Tech Journal*'s view is that IBM would have been crazy to give up compatibility with almost 10 million PC-compatible machines installed. IBM is not crazy.

IBM's challenge with the new family of machines was to build a platform for the future without sacrificing the past. As a result, the PS/2 models all run DOS, and all except the non-PS/2 Model 30 will run OS/2. *PC Tech Journal*'s testing reveals an extremely high level of software compatibility. The only programs with problems seem to be ones with hard-coded timing loops, hardware-specific graphics operations, or copy-protection schemes.

The machines are not without their incompatibilities; in fact, IBM has been introducing incompatibility with every new model for the last five years. Some of the changes were problematic, but none created the kind of long-term problems that cause buyer rebellion.

The PS/2 family falls into the same "mostly compatible" category. IBM exerted much time and energy to achieve this balance and deserves credit for making the effort.

3.5-INCH DISKETTES



I've said it before, and I'll say it again: it took guts, but IBM made the right choice. This pocket-sized media just has too much going for it. It's compact, rugged, simple, and has good capacity.

There's nothing else to say.

DATA MIGRATION



Well, perhaps there is one more thing to say: 3.5-inch diskettes in our 5.25-inch world are a colossal pain. The PS/2 family offers some options to deal with this problem, but not enough (see accompanying sidebar).

The extra ingredient needed to get this thumb turning up is internal 360KB and 1.2MB 5.25-inch drives for Models 60 and 80. Perhaps a smaller form-factor and 1.2MB support would take the sting out of the external drive. A 1.44MB 3.5-inch drive for the AT would be the frosting on the cake.

Whatever the solution, IBM deserves this rap on the knuckles for not following through with a complete set of solutions to back up its gutsy call.

HARD-DISK PERFORMANCE



For the PS/2 announcement, IBM went to some pains to position the family from a performance point of view. It even published a 15-page *Performance Guide* documenting how its conclusions about performance were reached.

There's some bad news, and there's some good news.

One piece of bad news involves the direct access storage device (DASD), IBM's acronym for a hard disk. IBM always seems to lag behind the competition in hard-disk performance. The drives on the Model 60 do not offer any performance increment over the AT 339 except that the interleave factor has been eliminated. Big deal—most serious hard-disk vendors dropped the interleave long ago, and most, especially Core International, have much higher performance. Even the compatible manufacturers, led by Compaq, regularly deliver machines with faster disks than IBM.

The Model 50's lowly disk performance is especially bothersome. This is

DATA MIGRATION DILEMMA

IBM simply has not gone far enough to support the inevitable data migration problems that end-user companies will face when PS/2 machines are integrated into the mainstream of PCs, XTs, ATs, and compatibles. The problem is tricky enough, even if all possible migration paths are covered. To ignore certain paths in favor of others is ill-advised (see table below).

IBM proffers three data migration options. The first is the previously announced internal and external options for XTs and ATs. The second is the new and elegant Data Migration Facility (photo 1 below), a cable connector between parallel printer ports that allows file transmission from XTs or ATs to the PS/2 models. The third option is IBM's aircraft-carrier-sized 5.25-inch External Diskette Drive (photo 2) for any member of the PS/2 family, including the Model 30.

The 3.5-inch drives for ATs and late-model XTs are a nuisance to install, but work well once that hurdle is past. Even the external drive is small and unobtrusive; it can be tucked out of the way beside the system unit, although it usually must be a few inches away from a monitor. Even so, these drives support only the 720KB format and are thus only partially helpful in moving data between Models 50, 60, and 80.

The official Data Migration Facility has the advantage of being very inexpensive at $33. However, it requires two adjacent computers and purely IBM parallel ports. Some parallel ports on multifunction adapters do not work with this option. Also, the data transfer is unidirectional; files can be transmitted from PC to PS/2, but not the other way around.

The last hope, the IBM external 5.25-inch drive, is almost laughable. While it provides a 360KB diskette drive on any PS/2, it consumes an expansion slot, must always be designated drive B:, and requires the second 3.5-inch bay on Models 50, 60, and 80 in order to connect the cable. And is it ever big. Its footprint on the desktop is 135 square inches, or more than half the size of a Model 30 system unit. Its volume is 354 cubic inches, or just under 40 percent of the volume of a Model 30. This is just not the diskette drive for the typical crowded desk space.

An external drive is the only solution feasible for Models 30 and 50. Models 60 and 80 have an open hard-disk bay that could have been used for 5.25-inch drives. I am not sure why IBM ignored this option.

Another puzzle is the lack of a 1.2MB option of any kind. It is as if that media—the default, delivered drive type for all ATs—just dropped out of sight. Does IBM believe that all the 1.2MB diskettes in use are suddenly going to disappear?

At *PC Tech Journal* we initially thought that the solutions offered by IBM would be satisfactory, albeit inconvenient. But when we seriously considered the PS/2s we already own or will be getting, and how we would handle certain work-flow situations, it became apparent that data migration was a more difficult problem than we had at first thought.

This is a useful exercise. Think about giving a key staffer a Model 50, while others in your organization retain ATs. Just how will they exchange data on a daily basis?

Perhaps IBM wants to propel us to the inevitable answer: networks.

—*WF*

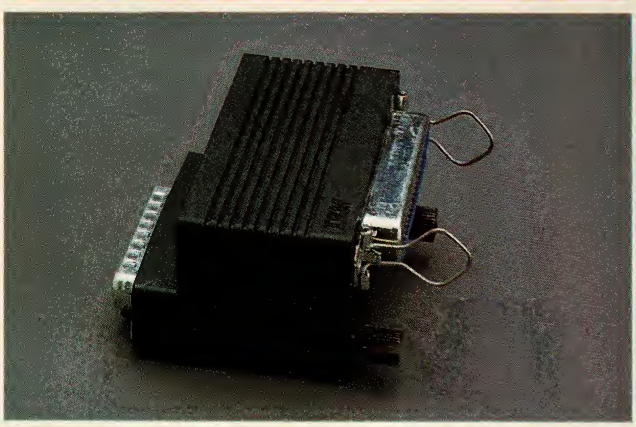
TABLE: *Solutions—Available and Recommended*

	3.5-INCH				5.25-INCH			
	720KB		1.44MB		360KB		1.2MB	
	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.
XT and AT	*	*	√	√	*		*	
PC Convertible	*		√					
Model 30	*		√			*		
Model 50			*			*		√
Models 60 and 80			*		√	*	√	√

* = *Available* √ = PC Tech Journal *recommendation* *Int.* = *Internal* *Ext.* = *External*

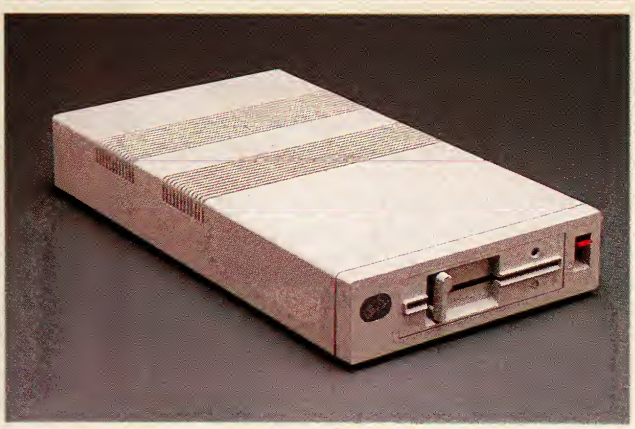
IBM should have gone further in supplying solutions for data migration.

PHOTO 1: *Data Migration Facility*



A simple parallel cable connector, with provided software, enables transfer of files from the older PC machines to the newer PS/2 family, but not vice versa.

PHOTO 2: *5.25-inch External Diskette Drive*



Big enough to land jet aircraft on, this external diskette drive is IBM's only offering for reading 360KB diskettes. Inexplicably, no support is provided for 1.2MB diskettes.

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Resident Run-Time System - has advanced program management features
XM™ - extended memory environment - runs your COBOL/2 applications in protect mode and switches to real mode for DOS services (needs AT or equiv.)

The COBOL/2 Software Development Kit is provided under Early Release Program with Bulletin Board support and free upgrades. Some of the products in the Kit are at Beta status. At the end of the Early Release Program, you will be updated with the general release versions of these. The Software Development Kit is available now at $1,500. At general release, Micro Focus COBOL/2 will be sold at $900 and the Software Development Kit, priced as separate products, would cost $1,775.

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undoubtedly another marketing ploy to prevent the low-end machine from encroaching on the territory staked out by IBM for the Model 60.

Even more annoying is that we get these hard disks of questionable performance whether we like them or not. IBM has correctly decided that mass storage should be a standard item, but that means we have to take the offered disk, even if we intend to upgrade—another good opportunity for the aftermarket suppliers, and another lost opportunity for IBM.

THE 2-MHz DIFFERENCE



Compaq just raised the performance of all its 286-based machines to 12 MHz. PC's Limited started this blitz some time ago, and just about everyone else delivers that speed as a matter of course. So why did IBM get stuck at 10 MHz?

Beats me, but IBM now faces a serious marketing problem, not because the difference between 10 and 12 MHz is great, but because IBM will be *perceived* to have lower performance.

Compaq made the speed tweak without changing the price. IBM should follow suit. In the meantime, Compaq and others will be laughing all the way to the bank.

CACHING IN



The decision to include disk-caching software with the PS/2 family was a stroke of marketing genius, a move that caught the competition flat-footed and made the PS/2 machines look much better than a raw performance analysis would otherwise indicate.

Disk caching is a useful, well-understood technique for improving the performance of a computer system. It can be especially helpful in certain data management situations, and that's a growing area. IBM gets an A+ for including the caching software with each machine (except the Model 30).

The competition is not taking this lying down, however. Compaq quickly responded with caching support for the Deskpro 386 and, as we were putting this issue to bed, for its 286 machines. Everyone else will certainly follow suit, and once they have, performance claims should level out.

PERFORMANCE METRICS



The way in which IBM has chosen to measure the performance of its new family is quite impressive, as is the uncommon openness it exhibited by using a set of third-party application software as the basis for the performance tests.

Products such as Microsoft Word, MicroPro's WordStar, Ashton-Tate's dBASE III, Microrim's R:base System V, Lotus 1-2-3, Autodesk's AutoCAD, Lattice C, and Borland's Turbo Pascal were used in carefully documented and controlled tests. The programs represent a good mix of CPU versus disk activity and random versus serial disk access. The results are appropriately vague, which is exactly what is to be expected when testing programs that could result in a range of performance depending on the particular circumstances of their execution. Nonetheless, the results do give a clear indication of the performance to be expected from a PS/2 machine when using a particular type of software.

The benchmarks IBM published illustrate the point *PC Tech Journal* has long made. Performance is a systems issue, not a point-by-point collection of isolated facts. It is the totality of those facts, in a specific environment, that defines performance.

The decision to include disk-caching software was a stroke of marketing genius, a move that caught the competition flat-footed.

IBM also avoided the trap of categorizing its machines as some factor faster than the previous generation and instead described a range of performance likely for a class of programs. In fact, it was so honest and diligent about testing that the overall performance rating for the Models 50 and 60 shows the low end as less than the best observed performance of the AT 339 (it was not quite diligent enough, however, to measure the performance of the AT with caching software).

This approach to performance measurement is much more meaningful and useful to the buyer. We encourage other vendors to follow IBM's lead.

THE CONCEPT



Overall, the PS/2 family is quite an impressive offering from IBM—more, in fact, than was expected. The idea of unifying the family of computers with common graphics subsystems, keyboards, bus, and more is a sound one. On paper the PS/2 family looks very good, very exciting. IBM's marketing story is also very strong, and the machines are an attractive alternative for IBM's most valued customers.

The family also embodies some very difficult choices in which IBM forged ahead and broke new ground. We may complain about the transition to 3.5-inch diskettes, but let's face it: we have been waiting for IBM to tell us what the standard would be for the next generation.

For IBM's cherished market, and for many other segments, the PS/2 family line is on the right track.

THE IMPLEMENTATION



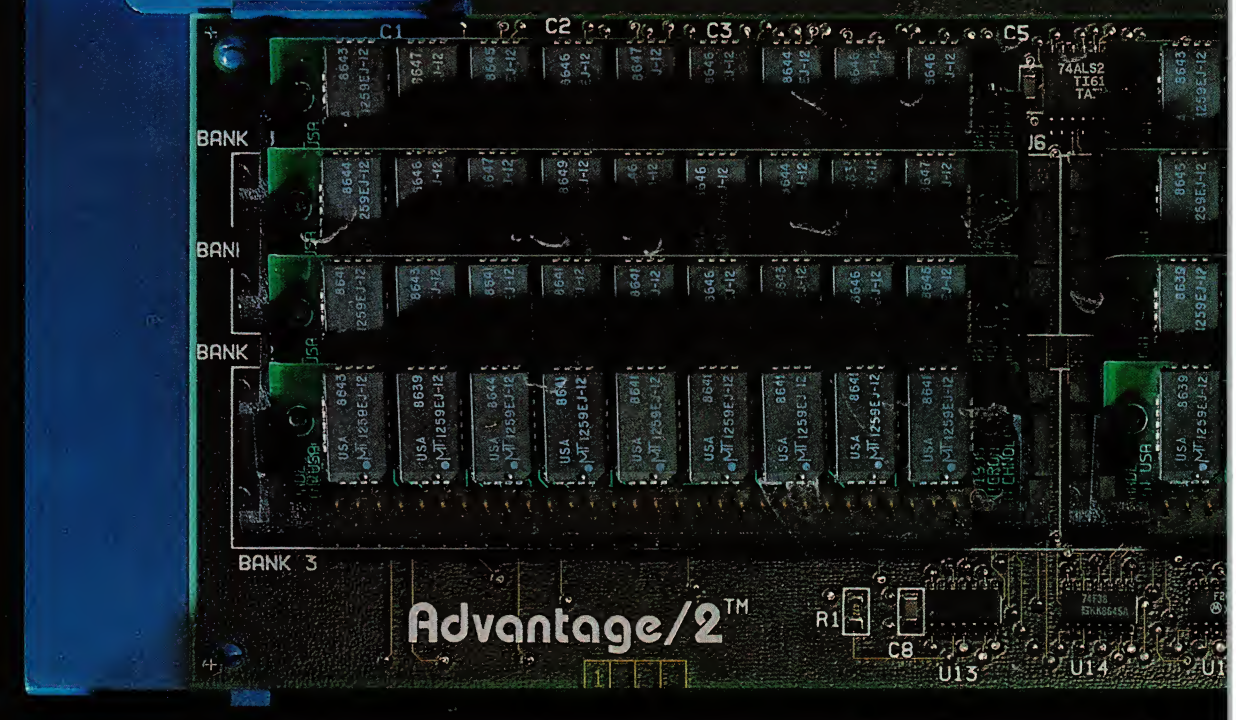
The real complaint is that IBM has been too conservative with the new machines, and this could spell trouble for the company in the long term. Two other industry leaders have taken some of the technological edge away from IBM: Compaq and Microsoft.

Compaq made the right choice by not waiting for IBM. Its product line looks very attractive right now, and I suspect that we will soon hear more on the pricing front and on the subject of new products. The Deskpro 386 definitely pushed the technology forward, and IBM lost the ability to claim technological leadership.

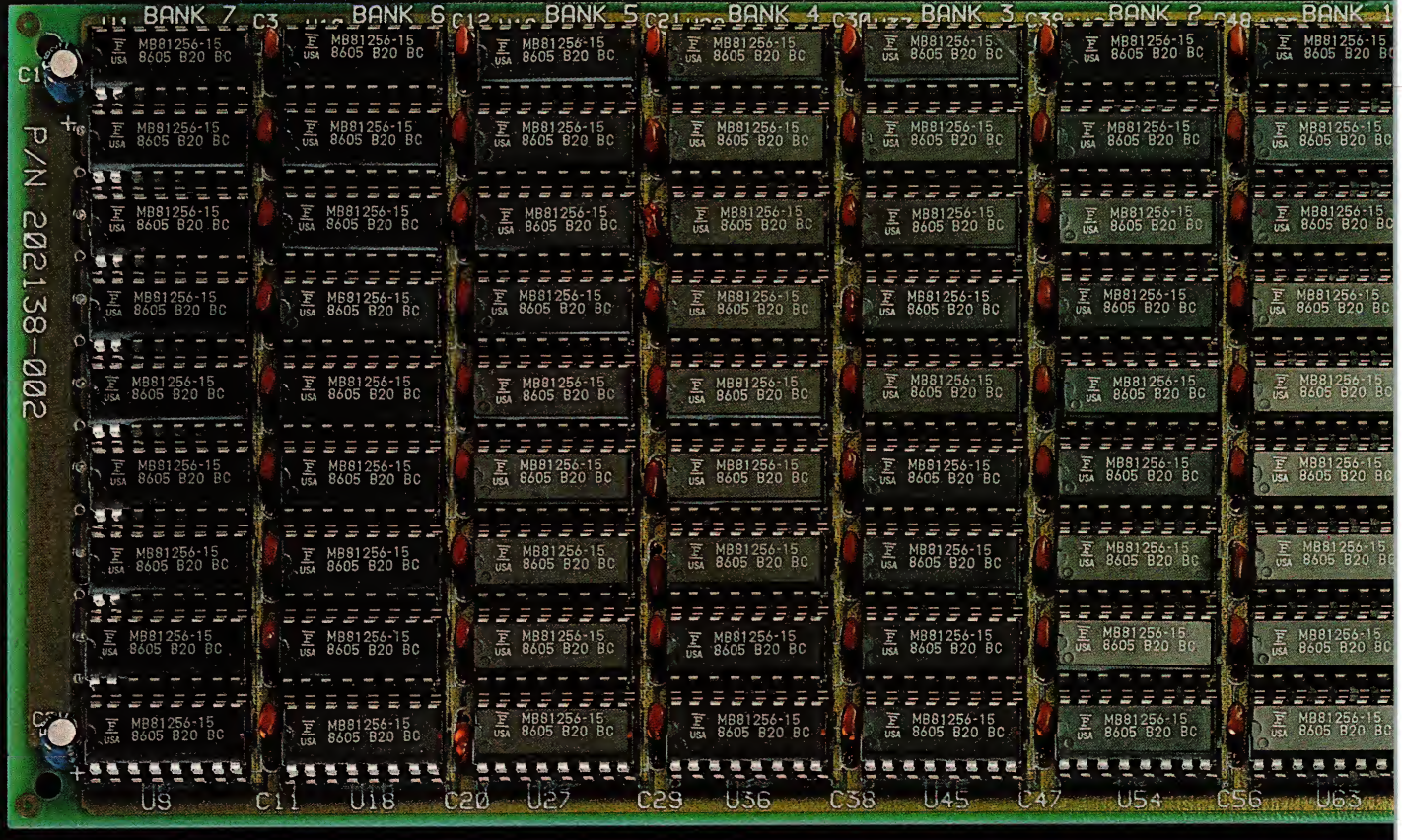
Microsoft, with its long vision, knew a graphical environment was going to be needed. In the face of an overwhelming lack of suitable hardware, it launched the Windows project. Windows was more than just a computer program; it was a missionary marketing effort, designed to make the IBM-compatible world understand the value of such a technology. IBM was left with little choice but to accept the technology and even the product (with some IBM touches added).

IBM has not stood idly by while technology marched forward, however. It exercised its clout, as only IBM can, to add a whole array of new features (the Micro Channel bus, VGA, 3.5-inch diskette drives) to personal computers. Unfortunately, the value of many of these features is not yet apparent to most PC users, nor will it be, unless and until OS/2 and appropriate applications are available to exploit these capabilities (not to mention the capabilities of the AT). In the meantime, IBM apparently expects its customers to pay full price now for capabilities that can only be fully used later.

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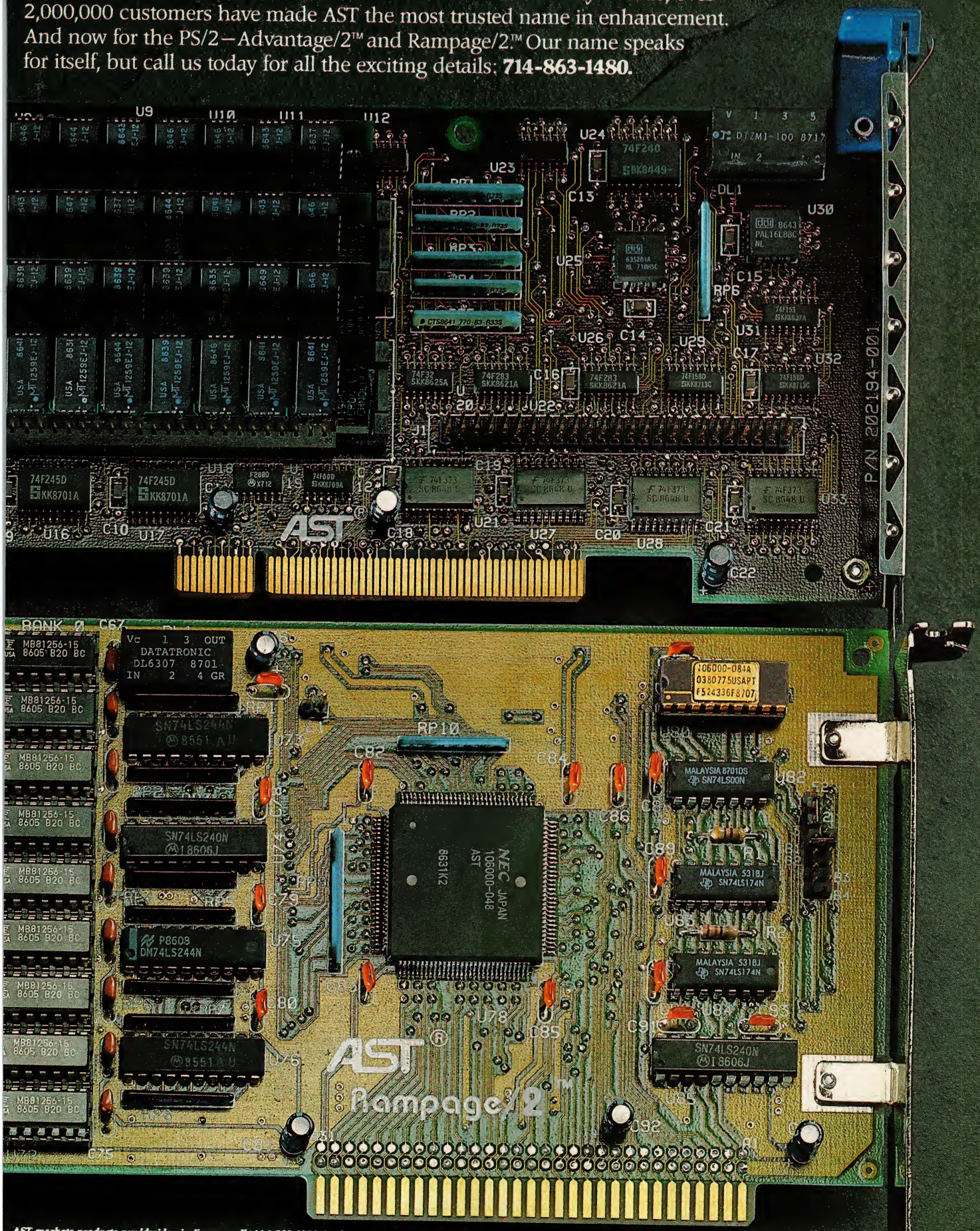


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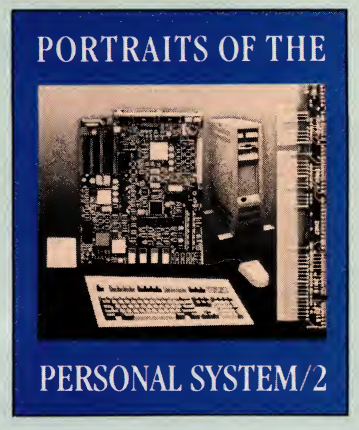
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An Architecture Redefined

IBM chose the middle ground for the architecture of Models 50, 60, and 80; it made radical changes in the hardware, including the new Micro Channel bus, while preserving compatibility with most software.

DAVID METHVIN

IBM faced a dilemma when designing the Personal System/2 (PS/2): although many design choices incorporated in the original PC have not held up well during six years of technological progress, significant changes would have made the substantial body of existing hardware and software unusable. For the PS/2 family, IBM chose a middle ground—the new computers incorporate major incompatible hardware changes, but also manage to preserve a high degree of compatibility with most PC software.

IBM's Micro Channel Architecture, the new expansion bus for PS/2 Models 50, 60, and 80, is perhaps the most radical change in the PS/2 design; because it is incompatible with the PC and AT buses, it is certainly one of the most controversial elements. However, the decision to change the bus is backed by sound reasoning; by beginning with a clean slate, IBM has escaped the limitations of a design from the Stone Age of personal computers.

At the same time, the PS/2 Model 30 still uses the PC bus, a guarantee that machines built around the PC and AT buses are not likely to disappear any time soon. In fact, the Model 30 may be considered a PS/2 in name only, lacking not only the Micro Channel but many of the system-board features of its siblings as well. (This article covers only the Micro Channel-based Models 50, 60, and 80.)

Despite the differences in hardware technology, the PS/2 line is upwardly compatible with PC and AT software; all of the familiar interfaces are present, even when the corresponding discrete support chips are missing. Of course, many new features in the PS/2 are not compatible with the PC and AT; for example, an entirely new direct memory access (DMA) channel interface is provided alongside the old, AT-compatible interface.

Another new feature is programmable option select (POS), which can be used with the IBM-supplied set-up software to determine and configure the features installed on the system board and adapters. POS replaces the switches and jumpers that are found on most PC-bus boards.

Unless IBM uses the legal system to protect its PS/2 design, the chances are good that other vendors will create compatible machines. With IBM's excellent documentation for the Micro Chan-

nel bus and software interface, a machine could be built that uses a very different hardware design, but furnishes the same interface for bus and software. Adapter cards and software that adhere to IBM's specifications should work flawlessly.

However, system functions are documented *only* by what IBM provides in its *Technical Reference* manuals. Each PS/2 model is defined only by interface descriptions supplied by IBM. Conceivably, undocumented functions could be hiding in the proprietary silicon that IBM could reveal in software a few years from now.

Two factors mitigate the effectiveness of such a tactic: third-party software that is written without the knowledge of a certain feature would be unaffected; and, only IBM's own software would want to limit its portability by exploiting these functions. For the ambitious Operating System/2 (OS/2) Extended Edition, version 1.1, IBM just might have that motivation.

A COMPLICATED SYSTEM BOARD

PS/2 Models 50, 60, and 80 have many new system-board functions in common. Although these functions are not part of what IBM calls the Micro Channel Architecture, they reflect many of the same design concerns, maintaining consistency throughout the family (except for the low-end Model 30).

The PS/2 system board is much more complicated than the AT board and depends more on proprietary custom-integrated circuits. It provides many functions previously supplied by adapter cards: video, parallel port, serial port, and mouse port. It also provides PC and AT hardware interfaces, although the circuitry that supports these interfaces is sometimes buried in IBM's proprietary silicon.

Custom gate arrays in the PS/2s replace many standard support chips for such functions as DMA controllers and programmable timers. Only the processor, math coprocessor, and ROM chips are socketed; much of the rest of the circuitry is surface mounted. The most obvious benefit of these changes is the smaller size of the system board, which makes possible small-footprint machines. Another advantage (to IBM) is that compatible manufacturers cannot easily duplicate the machines—IBM no longer uses off-the-shelf components or provides complete schematics.

Although the Micro Channel has changed the way that hardware generates interrupts, the software interface remains virtually unchanged. Two cascaded 8259 chips, identifiable on the system board, are used for interrupt control. Interrupt request (IRQ) 12, previously reserved, is now used by a built-in mouse ("pointing-device" in IBM parlance) port. The nonmaskable interrupt (NMI) no longer can be driven by adapter boards and is used on the system board primarily for signaling critical hardware faults.

Programmable timers, previously implemented by a discrete Intel 8254 chip, have disappeared into IBM's proprietary silicon. Timer 1, the memory-refresh timer, is gone, and its former I/O port location (41H) is now unused. Timer 3, the watchdog timer, has been added for use by the software (typically, the operating system) to detect when the system clock is not being serviced. This might occur when a wayward program disables the interrupts for a long period, possibly in an infinite loop. If the clock interrupt is ignored for the interval set in the watchdog timer, an NMI is generated, even if the NMI is masked on the system board. At present, this feature is disabled on power-up—perhaps it will be used by OS/2.

The Intel 8042 chip now provides the mouse interface in addition to handling the keyboard. The mouse and keyboard use the same 11-bit serial interface that consists of 1 start bit, 8 data bits, 1 parity bit, and 1 stop bit. The 8042 also implements an effective keyboard security scheme: a password can be loaded into the 8042 by the CPU, so that no keyboard input is accepted until that password is typed in.

The PS/2 uses an NS16550 chip to supply the on-board serial port. Although this chip has more features than the NS16450 used for serial ports on the AT, the PS/2 does not support any of the extra features. IBM now supports a 19,200-bps selection for serial port speed; the maximum speed on the AT is 9,600 bps.

The built-in parallel port has been enhanced with an extended mode that makes it bidirectional: it can be configured as either a transmitter or a receiver. A PC- or AT-compatible mode is also available. In the extended mode, bit 5 of the parallel port controls the direction of data transfer; this bit was previously undefined and has no effect in compatible mode. When bit 5 is set to 0, applications can write to the parallel port; when bit 5 is set to 1, applications can read from the parallel port. The other bits in the port perform the same functions that they have performed in previous systems.

A special parallel cable allows the transmitting end to drive the receiver's

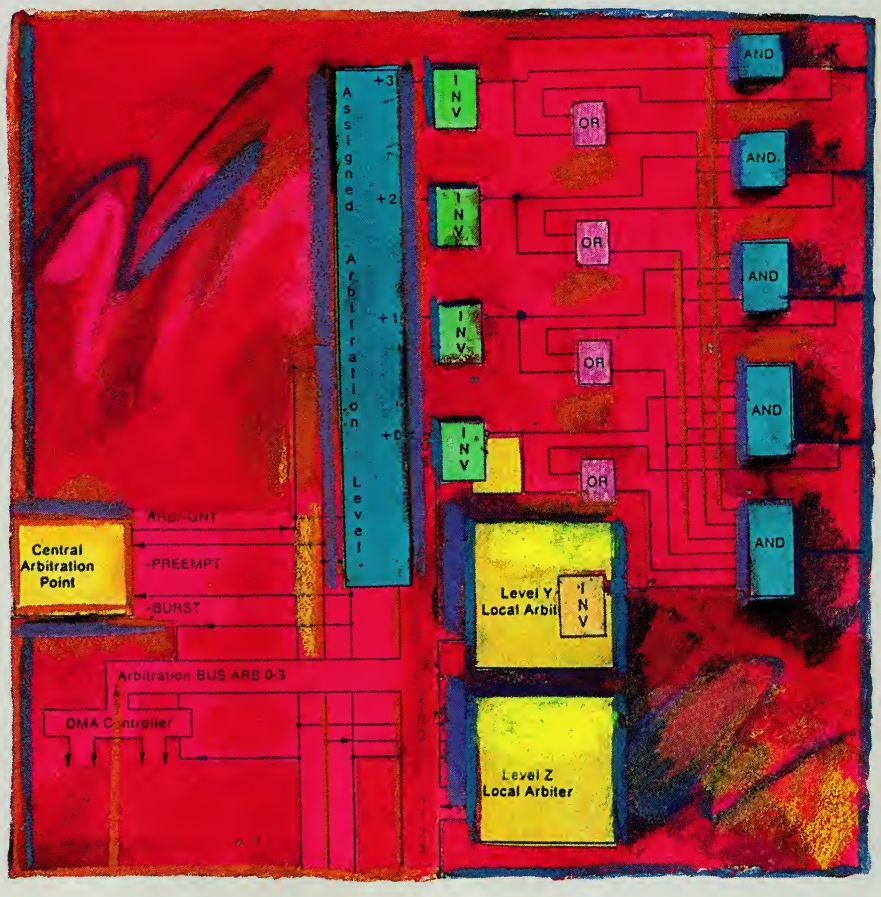


ILLUSTRATION • JANE STERRETT PHOTOGRAPHY • BLAKESLEE-LANE

acknowledge (ACK) line to handshake with the transmitter; IBM's Data Migration Facility performs this function. Only one end of the parallel cable can drive the eight data lines, so transmission is inherently half duplex. For two-way communications, software on both ends must establish a protocol to reverse the direction of the data, allowing the other end to transmit.

The bidirectional parallel port is a small but significant change. The strict design requirements of the Micro Channel bus are oriented toward the professional design engineer, not the home experimenter. The PS/2 parallel port provides a simple device interface that does not compromise the design goals of the Micro Channel.

The PS/2s provide a faster method for changing from protected mode to real mode in the 80286, but the AT method, which uses the 8042 and a status byte in CMOS RAM, is also present. The new method uses a bit in a system-control register; when set to 1, the bit pulses the processor reset line. When the system BIOS takes control, it checks the bit, still set to 1, and knows that a change from protected mode has taken place. The Model 80 also has this feature, even though the 80386 can use the more direct approach of resetting the processor status word.

As is the case in the AT, a Motorola MC148618A chip provides the real-time clock and 64 bytes of CMOS RAM. The RAM bytes defined in the AT are unchanged except that the hard-disk types are encoded differently. On the PS/2, bytes 11H and 12H contain the disk types for drives C: and D:, respectively, replacing the extended-byte method used on the AT. The reserved area starting at byte 19H contains the POS information on the Model 50. Models 60 and 80 each use a separate 2KB CMOS RAM for storing configuration data. IBM does not document how to access this RAM, information that applications do not usually need.

MICRO CHANNEL DIVERGENCE

The Micro Channel is a major divergence from the original PC and AT buses. In addition to the obvious differences in the physical shape of the boards and connectors, the Micro Channel uses different timings, signals, and protocols. (See the accompanying sidebar, "Physical Specifications.")

Bus transfers on the Micro Channel are asynchronous. A bus cycle is defined as a minimum of 200 nanoseconds (ns), but any device needing more time to complete a bus cycle can use a bus signal (CD CHRDY) to extend the cycle up to a limit of 3 microseconds. The actual minimum bus cycle depends on the particular PS/2 model: the 20-MHz versions of the Model 80 have a 200-ns bus cycle (in essence, 20 MHz with two wait states); the 16-MHz Model 80 has a 250-ns minimum bus cycle (16 MHz with two wait states). The Model 80, however, uses only one wait state for system-board memory and provides the Matched Memory protocol to increase performance of expansion memory. Models 50 and 60 have 300-ns minimum bus cycles (10 MHz with one wait state) for I/O and system memory, but support 200-ns memory on adapter cards.

Although the term *wait state* can describe Micro Channel timing, the actual cycle time should be specified; wait states depend on the speed of the processor and vary depending on when a device actually becomes ready. For example, an adapter that requires a 260-ns I/O cycle (by asserting CD CHRDY) does not need additional wait states on the Model 50, but extends the cycle by one wait state (62.5 ns) on the 16-MHz Model 80 and by two wait states (100 ns) on the 20-MHz model.

The PS/2 system board is much more complicated than the AT board and depends more on proprietary custom-integrated circuits.

Models 50 and 60 are particularly limited by their lack of fast memory-access time. Because access to memory is the most common activity on the bus, a design providing a 200-ns memory cycle for system-board memory would significantly have improved overall performance. However, this would have made the bus on the Model 50 faster than the bus on the 16-MHz Model 80. A desire to create a clear performance edge for the Model 80 probably led IBM to use the slower memory on Models 50 and 60.

The Micro Channel incorporates a flexible DMA scheme: eight DMA channels are available on the system board, and adapters also can perform DMA as bus masters. Although any DMA channel can be programmed to perform 8- or 16-bit I/O, the channels default to the AT-compatible DMA transfer widths at power-up for software compatibility. DMA can occur as a single cycle or as a burst (multiple-bus cycle) transfer. Access to the bus by competing DMA devices is accomplished through an *arbitration bus* (ARB00 through ARB03) with 16 levels of priority.

Another convenient feature is the AUDIO line and a separate AUDIO ground at the bus connector. This line connects to the built-in speaker; the speaker output is the sum of all boards that drive the AUDIO line. Expansion adapters such as modems or synthesizers can use the system speaker instead of incorporating another speaker. For higher fidelity, an adapter can receive the output of the AUDIO line and provide an output for an external amplifier, but the internal speaker cannot be disabled by software.

BUS RELATIONS

The Micro Channel Architecture encompasses a family of related bus interfaces (figure 1). The bus connector can contain five distinct interface sections: the 8-bit section, 16-bit extension, 32-bit extension, video extension, and matched memory extension.

The 8-bit section is the heart of the Micro Channel. Its 90 pins provide power (+5 volts, +12 volts, and −12 volts), ground, 24 address lines (A0 through A23), eight data lines (D0 through D7), interrupt requests (IRQ3 through IRQ7 and IRQ9), bus-arbitration control (ARB0 through ARB3, ARB/-GNT, and BURST), an audio bus, other control lines, and eight reserved lines. The address latch (ADL) line specifies when the address lines are valid. On the Micro Channel, this occurs early in the bus cycle. This longer period between a valid address line and the end of the cycle allows the system to use slower memory.

All slots in Models 50 and 60 (and five slots in the Model 80) include the 16-bit extension. Its 22 pins supply the additional eight data lines (D8 through D15) required for 16-bit data transfers; additional interrupt-request lines (IRQ10 through IRQ12, IRQ14, and IRQ15); and one reserved line.

The remaining three slots in the Model 80 use the 32-bit extension. These additional 62 pins provide 16 data lines (D16 through D31); eight address lines (A24 through A31) for access to the 80386's 32-bit data bus and 4GB address space; additional byte-enable lines (TR32 and BE0 through BE3) for control of the size and position of data transferred on the

PHYSICAL SPECIFICATIONS

The Micro Channel bus represents the clearest departure of the PS/2 design from previous architectures. The accompanying figure shows the general construction of a Micro Channel card, which is approximately 3 inches high by 11.5 inches long. The bus connector extends from the bottom by 0.5 inch. Components are limited to a height of 0.6 inch on the component side and 0.078 inch on the solder side.

At the front of the card (the end closest to the front of the system unit), a plastic *retainer* anchors the card to a guide slot. At the rear, a plastic *holder* insulates the card from contact with the cover. The retainer and holder also provide convenient handles for insertion and removal. An adapter's rear bracket is fastened and grounded to the system unit using a thumbscrew located on the system unit itself.

The 16-bit bus connector is 2.8 inches long and has 112 pins (half on each side); the 32-bit connector is 4.6 inches long and has a total of 174 pins. The pin spacing is 50 mils (a mil is 0.01 inch), which matches the pin spacing of surface-mounted devices. The resulting smaller connector requires a lower insertion and removal force than the PC bus.

To reduce the insertion force further, the edge of the bus connector is beveled at about a 20-degree angle. Because the beveling process tends to smear the gold from the contacts and short them together, the pins must either stop short of the beveling surface or be tapered as they reach the beveled area.

On some Micro Channel cards, the pins that supply power (+5 volts) are shorter than the others, reducing the possibility of power shorting to adjacent pins if the card is accidentally inserted or removed with power on. CMOS cards do not use this technique to prevent incorrect voltage bias from being applied to a component.

Pin A48, the +5-volt line adjacent to the key between the 8-bit and 16-bit bus sections, is unusual in cards having short power pins; instead of merely being short, the line makes a right-angle turn to the key opening. This is the vestigial remains of the gold-plating process for the power pins; during plating, a copper trace extends from pin A48 into the area that is later cut as the key, so that power can be applied for the electroplating process.

None of the unused lines on the bus is available for an adapter; they are reserved for future expansion. For applications that require two cards to communicate signals, the figure designates an area near the top front of the card that should be used for an edge connector. However, use of internal cables is discouraged, because they can block airflow. This concern for cooling is reflected in another design recommendation: the standard card dimensions must be followed to ensure proper airflow; half-size cards are not allowed.

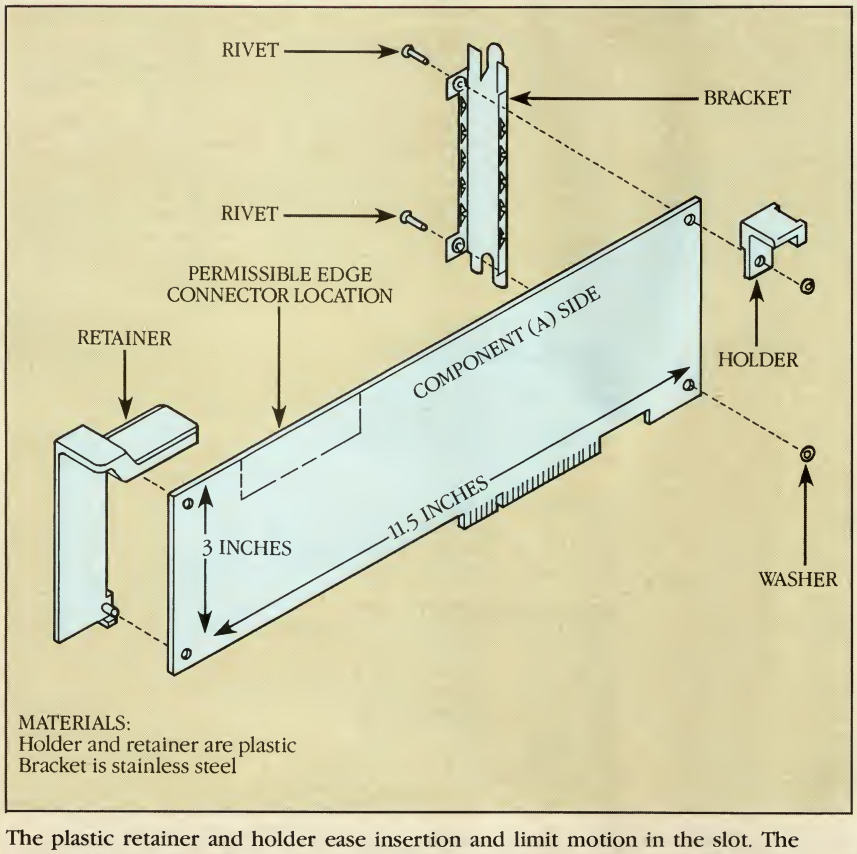
Another design consideration for the Micro Channel is electromagnetic interference (EMI). EMI is characterized by the equation $E = KAIF^2$, where K is a constant, A is a cross-sectional area, I is current, and F is the frequency. Because EMI increases by the square of the frequency, the area and current must be reduced to increase processor and/or bus speed.

The Micro Channel design attempts to reduce EMI. The bus connector is smaller, reducing the radiation area. The rear bracket of the adapter is isolated from the adapter's ground, limiting stray radiation. Power and ground lines are dispersed liberally throughout the bus so that any signal line is within 0.1 inch of a ground line (power lines are effectively grounds for EMI). A ground plane reduces EMI further. Other adapter design recommendations to reduce EMI are included in the *Technical Reference*.

Less power is available per slot on the Micro Channel: 1.6 amps at +5 volts, 0.175 amps at +12 volts, and 0.04 amps at −12 volts. For some designs, this may complicate the transition from the AT bus. Furthermore, low-power components are often more expensive, which may impact end-user cost.

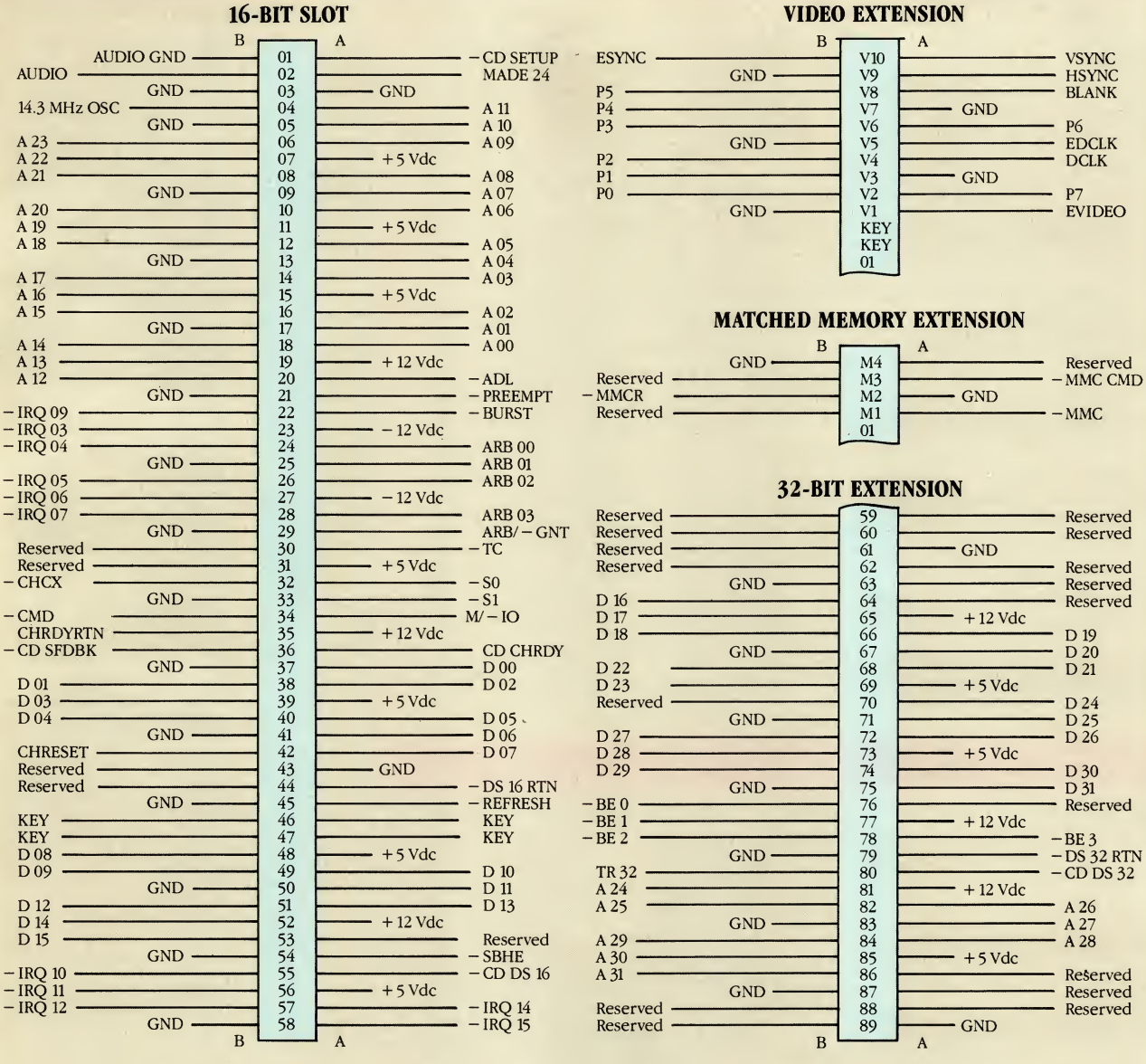
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FIGURE: *Micro Channel Construction*



The plastic retainer and holder ease insertion and limit motion in the slot. The rear bracket is isolated from ground to minimize electromagnetic interference.

FIGURE 1: *Micro Channel Signal Descriptions*



KEY TO SIGNALS

ADDRESS AND DATA CONTROL

A0 to A31	Address bus
ADL	Address decode latch
D0 to D31	Data bus
CMD	Command (data bus valid)
M/–IO[a]	Memory/IO cycle
MADE 24	Address less than 16MB (24 bits)
S0, S1	Status (read/write)

DATA SIZE AND POSITION

CD DS *nn*	16/32-bit device access[b]
DS *nn* RTN	Negative OR of all CD DS *nn* lines
TR 32	Translate 32-bit accesses
BE *n*	Data present on byte *n*
SBHE	System byte high enable (D8 to D15)

DMA AND BUS ARBITRATION

ARB *nn*	Arbitration bus
ARB/ – GNT[a]	Arbitrate/grant cycle
BURST	Burst (multiple cycle) transfer
PREEMPT	Preempt (arbitration request)
TC	Terminal count

MATCHED MEMORY

MMC	Matched memory cycle possible
MMCR	Matched memory cycle request
MMC CMD	Matched memory cycle command

OTHER CONTROL/STATUS LINES

CD SFDBK	Card selected feedback[b]
CD SETUP	Card set-up[b]
CD CHRDY	Channel ready[b]
CHRDYRTN	AND of all CD CHRDY lines
CHCK	Channel check
CHRESET	Channel reset
REFRESH	Memory refresh cycle
IRQ *nn*	Interrupt request *nn*

[a]A – preceding a signal indicates that it is active in the low (ground) state.
[b]These signals are not bused; they are unique lines to each slot.

Three types of Micro Channel slots are defined: 16-bit, 16-bit with video extension, and 32-bit with matched memory extension. The 32-bit version is present only in the Model 80. Adapters that perform only 8-bit I/O can eliminate the connector for pins 49 through 58. Power and ground lines are dispersed throughout the bus to help eliminate electromagnetic interference.

32-bit bus; and 16 reserved lines. All 32-bit expansion slots include the matched memory extension, which allows 32-bit expansion boards to exploit high-performance memory timing.

For all reserved lines on the bus, IBM warns in the *Technical Reference*: "Any signals shown or described as 'Reserved' are not to be driven or received. These signals are reserved to allow compatibility with future implementations of the channel interface. Serious compatibility problems, loss of data, or permanent damage can result to features or the system if these signals are misused."

In each of the three PS/2 models, an extra connector in one slot supplies the video extension, which allows add-on boards to control the built-in interface to the video display. This arrangement provides a video board with the system board's Video Graphics Array (VGA) modes eliminating the need to duplicate the video-driver circuitry.

Photo 1 shows the three types of slots that are supported on the Model 80 system board: 16-bit, 16-bit with video extension, and 32-bit. Photo 2 shows the 16-bit Micro Channel connector for a typical adapter.

SIMPLIFYING WITH POS

The set-up programs of Models 50, 60, and 80 are noticeably different from the PC set-up; the program itself selects the assignments of the built-in serial and parallel ports and configures options on adapters, all without setting jumpers or switches. Much of this program depends on the POS feature, which makes system and adapter configuration much easier than on PCs.

Each adapter designed for the Micro Channel must have a 16-bit *adapter ID* that indicates its type. For example, the IBM Multi-Protocol Communications Adapter uses 0DEFFH and the IBM Token-Ring Adapter/A uses 0F000H. These numbers allow the set-up software to identify and configure each adapter properly.

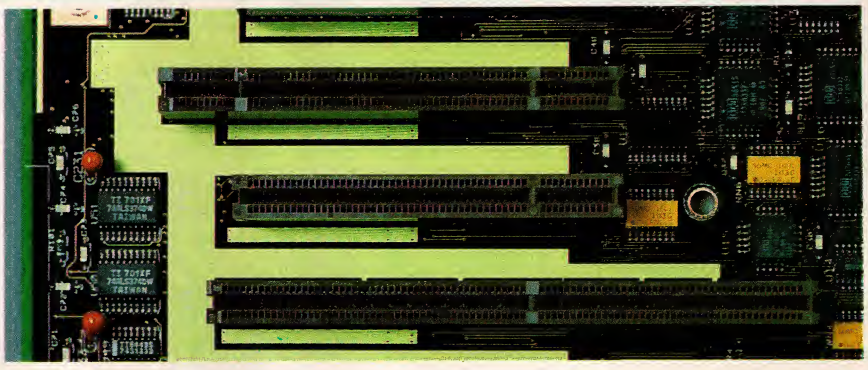
IBM is currently offering to manage the allocation of third-party developers' adapter IDs through a hot-line number (305/241-5455). IBM also recommends that vendors use adapter IDs in the range of 0H to 7FFFH and provides a general classification scheme for vendor-supplied adapters (table 1).

Because open collector drivers are used, only the 0-bits in an adapter ID require a bus driver; all other bits are 1. This is why IBM chose the value 0FFFFH to mean "adapter not present." It is also why IBM reserves IDs in the range from 8000H to 0FFFEH for IBM boards—it reduces logic on the board.

The vendor must accompany each Micro Channel adapter with a diskette containing an adapter description file (ADF) that describes all resources required by the adapter, including interrupts, memory addresses, and I/O addresses (see the accompanying sidebar, "Adapter Description File"). Wherever a choice of configurations is possible (for example, ROM-address location), the ADF specifies the values that are used to select each particular configuration. The vendor also can provide an optional diagnostic routine overlay on the diskette that the set-up program can use to test the adapter.

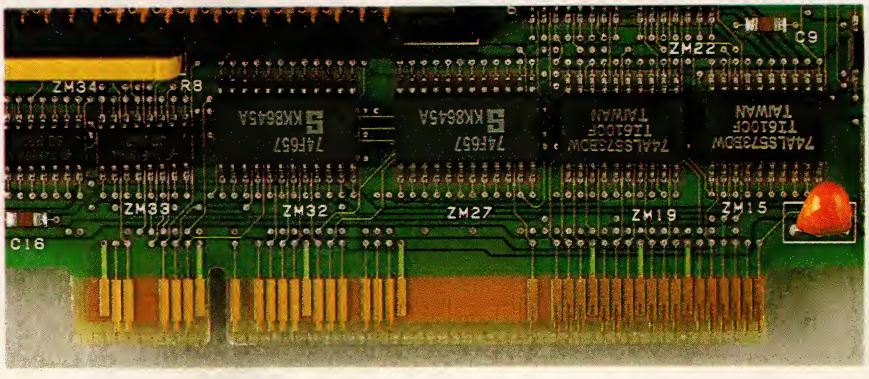
The set-up program contained on the IBM Reference Diskette supplied with each Model 50, 60, and 80 provides an elegant interface for modifying

PHOTO 1: *Micro Channel Slots*



Three types of slots are used by the Micro Channel; only the Model 80, shown here, contains all three. From top to bottom, they are: 16-bit slot with video extension, 16-bit slot, and 32-bit slot with matched memory extension.

PHOTO 2: *16-bit Micro Channel Connector*



The 8-bit and 16-bit sections of the bus are separated by a key that is two pins wide to align the card accurately. The edge is beveled to reduce insertion force.

TABLE 1: *Adapter ID Assignments*

ID	DEFINITION
0000	Device not ready
0001 to 0FFF	Bus master
5000 to 5FFF	Direct memory access devices
6000 to 6FFF	Direct program control (including memory-mapped I/O)
7000 to 7FFF	Storage[a]
8000 to 8FFF	Video
FFFF	Device not attached

[a] *Multiple-function adapters containing storage typically respond as storage.*

IBM reserves adapter ID numbers 9000H through FFFEH for its own use; this reduces logic on the board. The remaining values are available for third-party developers. This classification facilitates system diagnosis and configuration procedures.

ADAPTER DESCRIPTION FILE

Although many of the Micro Channel's features are a result of hardware transformations, some of the improvements are due to changes in software. In many cases, the Micro Channel merely provides hooks to control and diagnose hardware; software must take up the slack.

This synergy between software and hardware is best demonstrated by the system set-up program for Models 50, 60, and 80. Using a hardware facility, the set-up program determines which adapters are present. It then looks for the adapter description file (ADF) to direct the configuration process. The adapter manufacturer must provide the ADF on a diskette with its product.

The ADF is a text file that describes the resources (I/O, memory, interrupts) required by an adapter. It may be viewed by using the TYPE command or a standard ASCII editor. ADF syntax is described in detail in the PS/2 Models 50 and 60 *Technical References*. For each option, the ADF specifies the values that must be written to the adapter's programmable option select (POS) configuration registers to select those resources. Each choice includes a text string that describes that option. The item also can include a help entry that can be displayed for further information.

A sample ADF for the IBM Multi-Protocol Communications Adapter is shown in the accompanying figure. Because the adapter ID is 0DEFFH, the ADF would be named @DEFF.ADF. This simple naming convention allows the set-up program to find each adapter's corresponding ADF; it merely queries the board for the adapter ID and converts it into a file name. Input is relatively free-form: information can be condensed onto one line or spread across multiple lines; numeric values can be specified in hexadecimal, binary, or the default decimal; multiple-line help messages, surrounded by double quotes, can be provided for any prompt.

The NumBytes entry near the top of the ADF indicates how many option set-up registers are implemented on the adapter; up to four bytes of configuration data are directly supported. If more set-up data are required, a secondary enable bit is implemented to disable the adapter until a driver can finish the configuration after power-up. An optional FixedResources entry specifies any resources the adapter needs that are not changeable and that might include an I/O port address or interrupt-request line. ROM and RAM locations should be selectable, rather than fixed, resources.

A NamedItem entry has three components: prompt, choice, and help. The prompt string describes the option being selected; each choice specifies the resources that the choice requires (the **io**, **int**, **arb**, and **mem** entries) and the values needed to select that choice (the **pos** entry). A digit specified as *X* means that the corresponding bits should not be changed.

The set-up program's automatic-configuration option uses ADF information to configure the entire system without manual intervention. For each adapter, the program selects the first nonconflicting choice in a NamedItem list. However, if it cannot find a nonconflicting choice, automatic configuration fails; the program does not attempt to backtrack and configure a previous adapter to resolve the conflict.

For example, IBM's 3270 Connector for its Micro Channel–based machines uses a nonconfigurable address of 0CE000H through 0CFFFFH for RAM. If another board that already has been configured chooses this address, then automatic configuration fails when it tries to configure the 3270 adapter. By editing the ADF, choices can be rearranged in the first adapter's NamedItem list in order to make the 0CE000H address a last resort.

the configuration. First, it queries the expansion slots for adapters and retrieves an adapter ID; next, it searches the Reference Diskette for corresponding description files; then, it parses the files to determine what configuration options are available.

The user can change the configuration through a menu and function-key interface. In addition, an automatic configuration mode allows the system to choose default settings for the adapters and system board without user intervention. If a conflict occurs (such as overlapping ROM areas in two adapters), automatic configuration recognizes the conflict and requires the user to resolve it, possibly by removing one of the conflicting adapters.

System-board options are configured using the same method: the parallel port can be configured as LPT1, LPT2, or LPT3, and the serial port as either COM1 or COM2. The VGA, diskette controller, parallel port, or serial port also can be disabled and supplanted by an expansion adapter.

Once the configuration has been established, the set-up program writes the selected values into the battery-backed CMOS RAM and restarts the system as if it had just been powered on. During the system's power-on self-test (POST) procedure, CMOS RAM is tested for inconsistency (for example, loss of battery power) using the cyclic redundancy check that was stored at set-up. Then the adapter IDs found in the system are compared with the adapter ID that was stored in CMOS RAM during set-up. If any discrepancies are found, POST displays one or more error codes on the screen.

If the configuration has not changed, the POST initializes the system board and adapters with the values saved in CMOS RAM during set-up. An I/O port (0096H) on the system board selects the adapter being configured by driving the unique CD SETUP line for an adapter slot. The selected adapter responds to I/O port addresses 0100H through 0107H during configuration to set the on-board POS data. While being configured, an adapter does not respond to any other memory, I/O, or bus arbitration requests.

All adapters have certain information in common, available at defined locations in the configuration I/O ports. Ports 0100H and 0101H always house the adapter ID. In other ports, an adapter enable bit is provided to disable a board so that it does not respond to memory or I/O requests or generate interrupts. A channel check active indicator bit drives the channel-check (CHCK) bus line; the bit signals that the adapter has encountered a serious error, such as a parity error. A 16-bit channel-check status indicator (an error code, for example) is an option.

If an adapter requires memory, it also should support configuration-option fields to determine which ad-

FIGURE: *Sample ADF*

```
AdapterId 00EFFh

AdapterName "IBM Multi-Protocol Communications Adapter"

NumBytes 2

NamedItem

Prompt "Communications Port"

choice "SDLC 1"    pos[0]=XXX1000Xb  io 0380h-038ch  int 3 4
choice "SDLC 2"    pos[0]=XXX1001Xb  io 03a0h-03ach  int 3 4
choice "BISYNC 1"  pos[0]=XXX1100Xb  io 0380h-0389h  int 3 4
choice "BISYNC 1"  pos[0]=XXX1101Xb  io 03a0h-03a9h  int 3 4
choice "SERIAL 1"  pos[0]=XXX0000Xb  io 03f8h-03ffh  int 4
choice "SERIAL 2"  pos[0]=XXX0001Xb  io 02f8h-02ffh  int 3
choice "SERIAL 3"  pos[0]=XXX0010Xb  io 3220h-3227h  int 3
choice "SERIAL 4"  pos[0]=XXX0011Xb  io 3228h-322fh  int 3
choice "SERIAL 5"  pos[0]=XXX0100Xb  io 4220h-4227h  int 3
choice "SERIAL 6"  pos[0]=XXX0101Xb  io 4228h-422fh  int 3
choice "SERIAL 7"  pos[0]=XXX0110Xb  io 5220h-5227h  int 3
choice "SERIAL 8"  pos[0]=XXX0111Xb  io 5228h-522fh  int 3

Help

"This port can be assigned as a: primary (SDLC1) or
secondary (SDLC2) sdlc, primary (BISYNC1) or secondary
(BISYNC2) bisync, or as a serial port (Serial 1 through Serial 8).
Use the F5-Previous and the F6-Next keys to change this
assignment.  Conflicting assignments are marked with an
asterisk and must be changed."
```

```
NamedItem

Prompt "Arbitration Level for SDLC"

choice "Level 1"   pos[1]=XXXX0001b  arb  1
choice "Level 0"   pos[1]=XXXX0000b  arb  0
choice "Level 2"   pos[1]=XXXX0010b  arb  2
choice "Level 3"   pos[1]=XXXX0011b  arb  3
choice "Level 4"   pos[1]=XXXX0100b  arb  4
choice "Level 5"   pos[1]=XXXX0101b  arb  5
choice "Level 6"   pos[1]=XXXX0110b  arb  6
choice "Level 7"   pos[1]=XXXX0111b  arb  7
choice "Level 8"   pos[1]=XXXX1000b  arb  8
choice "Level 9"   pos[1]=XXXX1001b  arb  9
choice "Level 10"  pos[1]=XXXX1010b  arb 10
choice "Level 11"  pos[1]=XXXX1011b  arb 11
choice "Level 12"  pos[1]=XXXX1100b  arb 12
choice "Level 13"  pos[1]=XXXX1101b  arb 13
choice "Level 14"  pos[1]=XXXX1110b  arb 14


Help

"This assignment need only be changed if it is in conflict
with another assignment.  Conflicting assignments are marked
with an asterisk.  Use the F5-Previous and the F6-Next keys
to change arbitration level assignments.  Using arbitration
levels, this adapter accesses memory directly without
burdening the computer's main microprocessor.  An
arbitration level of 0 has the highest priority, and
increasing levels has corresponding decreased priority."
```

The ADF provides a readable description of an adapter's configuration that can be used by the system's set-up program.

The Reference Diskette that IBM supplies with each PS/2 machine contains only the configuration and diagnostics for the built-in features of the machine. Before any expansion adapter is added, the set-up program should be used to copy the ADF from the diskette that the vendor supplies with the adapter onto the Reference Diskette.

The adapter can then be installed and configured either manually or automatically. A master Reference Diskette containing ADFs for all adapters in use should be maintained for installations that have a variety of options installed. This greatly simplifies the process of reconfiguring a system during installation or after catastrophic failures.

—DM

dress to use. The location of this field is not mandated by the Micro Channel specification; it can be placed in any of the POS registers. The memory-address field should specify one of the sixteen 8KB segments between 0C0000H and 0DFFFFH. (The 64KB starting at address 0E0000H is occupied by a portion of the ROM BIOS.)

The requirement for selectable I/O addresses is more ambiguous. According to IBM, "All I/O devices that can simultaneously reside in a system *with a device of the same type* must support a programmable I/O device field" [emphasis added]. I/O addresses are not limited to 3FFH as in the PC—they can be located anywhere in the 16-bit I/O address space. This creates a problem similar to the problem in assigning adapter IDs: many I/O addresses are available, but no procedure has been defined to exclusively assign them. An I/O address map is supplied only for system-board functions and does not enumerate even the IBM adapters. Cautious developers should provide for a selectable I/O address and avoid the region from 0H to 3FFH in I/O space.

Although not required, a selectable interrupt-request line for adapters is recommended. Interrupt chaining allows multiple devices to share a single interrupt line. However, if many devices share the same line, responses to some interrupting devices may be degraded. Selecting a free interrupt-request line improves performance.

Once a board has been configured, the information that must be kept for reconfiguring during power-on is reduced to a maximum of six bytes: the two-byte adapter ID and the four configuration-register values. Because the information in the ADF is not available to the system during normal operation, the ROM BIOS's handling of system faults is impaired. For example, although the system board can detect bus time-outs and obtain the arbitration level of the board that caused the time-out, the board assigned that arbitration level can be determined only with the help of information in the ADF—available only during set-up.

One untapped benefit of the POS feature is fault tolerance. Identical, redundant adapter cards would be placed in the system, but only one of the cards can be used until a failure is diagnosed. POS or custom software could disable the failing card and initialize an alternate card.

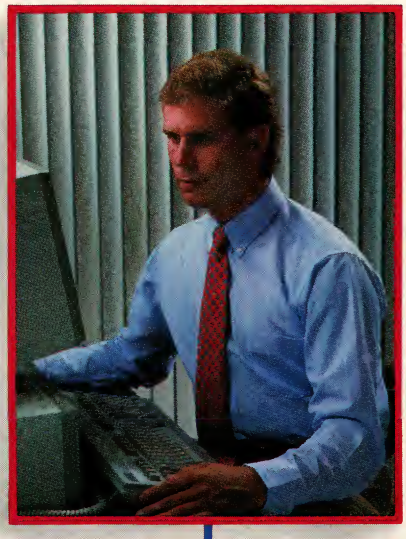
LEVEL-SENSITIVE INTERRUPTS

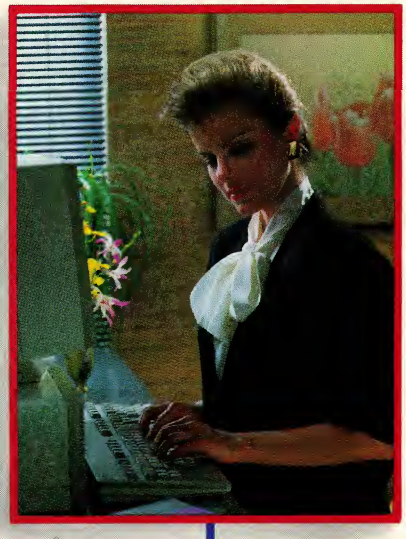
The Micro Channel uses a level-sensitive interrupt mechanism, in contrast to the original PC bus, which uses an edge-triggered approach. The major benefits of level-sensitive interrupts are simplified adapter interrupt-request hardware and improved detection of lost or spurious interrupts.

When a Micro Channel adapter wishes to signal an interrupt, it drives

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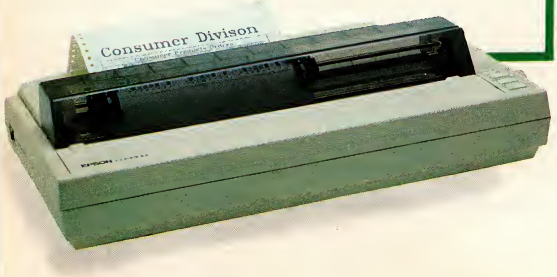
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its assigned interrupt-request line into the low state. In addition, it must set an interrupt-pending bit that software is able to read. The processor then can begin executing at the location specified by the corresponding interrupt-vector address.

A hardware interrupt-service routine (ISR) must behave as a software interrupt routine that hooks a vector such as interrupt 21H. It must save the existing vector address when it installs itself. When an interrupt occurs, the ISR checks its device for an interrupt using the interrupt-pending bit. If its device is interrupting, the ISR services the device, clears the interrupt, and then returns using IRET. If not, it chains to the next device using its interrupt-request line.

This method of chaining hardware interrupts is not new, having been documented in the *AT Technical Reference* since the 6-MHz AT was released. However, by then a large body of code already existed that was not able to share interrupts. Software developers have largely ignored the technique.

IBM has not given up, however; the interrupt-sharing procedure is fully described in the *Personal System/2 and Personal Computer BIOS Interface Technical Reference*. It includes prototypical assembly language routines for linking and unlinking an ISR into the chain and for processing an interrupt. It also provides details of the interrupt-sharing structure. IBM's definition of the FIRST flag is somewhat confusing; the first ISR to load sets its FIRST flag, but it actually is the *last* ISR encountered as the chain is traversed.

DMA/BUS ARBITRATION

The Micro Channel provides an excellent interface for devices that wish to control the bus for operations such as DMA transfers. It allows both single cycle and burst-mode transfers and uses a 16-level preemptive priority scheme. An optional "fairness" feature can prevent a high-priority device from usurping the bus after being preempted. Devices can perform 8-bit or 16-bit transfers; although the Model 80 has a 32-bit bus, it does not support 32-bit DMA transfers.

Each device participating in bus arbitration is assigned a unique four-bit *arbitration level*, with lower-numbered levels having higher priorities. The eight DMA channels on the system board initially are assigned arbitration levels 0 through 7, but channels 0 and 4 can be reprogrammed to any level. IBM designates levels 8 through 14 as reserved; the system microprocessor uses level 15 (the lowest priority).

The central arbitration control point (CACP) on the system board governs bus arbitration. By retaining control over the bus, the CACP prevents detrimental use of the bus and is able to detect error conditions.

A device that wishes to control the Micro Channel signals its request using the PREEMPT line. After completing the current bus cycle, the CACP begins a bus arbitration cycle by activating the ARB/-GNT line. Each device requesting the bus then drives its arbitration level onto the arbitration bus (ARB0 through ARB3). Circuitry on each device, called the *local arbiter*, then is able to detect when a lower-numbered device is driving the bus and defers its request to the next arbitration cycle. The device with the lowest-numbered arbitration level is therefore granted control of the bus by the CACP on the transition of the ARB/-GNT line.

The Micro Channel uses a level-sensitive interrupt, in contrast to the original PC bus, which uses an edge-triggered approach.

On Models 50 and 60, an arbitration cycle usually takes 300 ns. The 16-MHz Model 80 has a 375-ns arbitration cycle because this value is the next convenient multiple of the processor clock above the 300-ns minimum time. However, the CACP recognizes the special case of a request by level zero and can reduce the cycle to as little as 100 ns. A control bit on the system board also can be set to enable extended arbitration, thereby doubling the arbitration period. A longer arbitration cycle might be needed, for example, if a bus expansion unit is added. The extended arbitration would allow more time for longer propagation delays through the bus expansion unit.

Two special arbitration levels are defined that can be generated only on the system board: level −1 is the NMI and level −2 is memory refresh. These levels have higher priority than level 0 and therefore receive preferential treatment. As in the standard case, CACP initiates an arbitration cycle by activating the ARB/-GNT line. However, the bus stays in the ARB state while the NMI and refresh operations are being performed, effectively disabling any DMA devices. For the NMI, the system processor owns the bus until the NMI is cleared. For memory refresh, the refresh line is activated.

A device can perform a burst transfer by asserting the BURST line after it has been granted the bus. While the device is operating in the burst mode, another device can request the bus by asserting the PREEMPT line. The device that currently has the bus must relinquish it within 7.5 microseconds. Then, a new arbitration cycle is initiated. The winner of this new arbitration cycle must also obey the PREEMPT line if it remains asserted. Thus, any bus grant awards a minimum of 7.5 microseconds to the winning device. Memory refresh occurs every 15.6 microseconds, so the maximum bus grant time is 23.1 microseconds.

Any arbitrating device must provide two software-selectable options to allow better control over system performance: a selectable arbitration level and a fairness feature that prevents a single high-priority device from continually usurping the channel. When fairness is enabled for a device, that device does not participate in arbitration cycles until all preempting devices have been served. By default, fairness is enabled for all arbitrating devices and guarantees that the CACP eventually will service all devices, regardless of their priority levels.

The Micro Channel's arbitration scheme is a major improvement over the AT bus. The AT bus has an 8-level priority scheme, as opposed to the Micro Channel's 16 levels, and only certain levels can perform 8-bit or 16-bit transfers. If a PC bus device wishes to control the bus for more than one cycle, it can drive the bus master line. However, the device then has such absolute control that no other device can preempt it—even memory-refresh cycles are prevented. The PC bus has no equivalent to the fairness feature or the burst-mode arbitration that is provided by the Micro Channel.

DMA FUNCTIONS

System board DMA functions are no longer provided by Intel 8237 chips; instead, one of the IBM custom chips supplies an 8237-compatible interface. All eight DMA channels have 24-bit address capability and can perform 8-bit or 16-bit transfers. In addition, the PS/2 provides a new, more coherent method of programming the DMA

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channels called *extended operation*. The AT-compatible mode requires 38 separate I/O ports; the function desired and the channel being programmed determine which I/O port must be used. In extended operation only two ports are used: an output to the function register port (18H) selects the channel to be programmed and the operation to be performed; an output to port 1AH executes the function.

A DMA transfer begins when a DMA slave device is granted the bus and the corresponding DMA channel has been programmed to service it. DMA channels 1 through 3 and 5 through 7 can service only their identically numbered arbitration levels.

The *virtual DMA* feature increases the capability of the built-in DMA channels even further; because DMA channels 0 and 4 can be programmed to any arbitration level, they can be used to service multiple DMA slaves by multiplexing the DMA channels between the arbitration levels assigned to those slaves. This allows two DMA channels to support up to nine devices (arbitration levels 0, 4, and 8 through 14).

Alternatively, a device can be designed as a bus master and perform its own I/O by driving the address, data, and other control lines. The primary advantage of a bus master is that it can typically perform a transfer in half the time that a DMA slave could perform the same transfer. This is because a DMA slave must be serviced by two bus cycles per unit (byte or word) of data transferred.

Multiple masters can reside on the bus, and the Model 80 can accommodate 32-bit masters. Multiple bus masters, combined with the arbitration scheme, facilitate the design of intelligent concurrent processors. The CHRDYRTN, DS16RTN, and DS32RTN lines are provided so that bus masters on adapter cards can monitor the readiness and data size of other adapters and system board components.

As is the case in the AT, DMA channel 2 is used for the diskette controller on all models of the PS/2. This implies that the diskette controller uses arbitration level 2. Because the NMI, memory refresh, and arbitration levels 0 and 1 can preempt the diskette controller, IBM warns that these high-priority devices should have limited bandwidth or short bursts in order to prevent a data overrun in the diskette controller. An overrun occurs if the controller is held inactive for more than 12 microseconds; the BIOS then detects the overrun and retries the operation. The hard-disk controller uses arbitration level 3 by default, but the POS feature can be used to program the controller to another level.

TABLE 2: *New PS/2 BIOS Functions*

FUNCTION	DESCRIPTION
INT 10H (Video)	
Various	(EGA BIOS functions incorporated)
1AH	Read/write display combination code
1BH	Return functionality/state information
ICH	Save/restore video state
INT 14H (Asynchronous Communications)	
04H	Extended initialize
05H	Extended communications port control
INT 15H (System Services, formerly Cassette I/O)	
C1H	Return extended BIOS data area address
C2H	Mouse BIOS interface
C3H	Enable/disable watchdog timer
C4H	Programmable option select (POS)

Although the ROM BIOS area doubled in size, only a few new functions were added. Most support hardware features, such as the mouse port and VGA modes.

VIDEO EXTENSION

The Micro Channel turns video support on the PS/2 system board into an advantage for add-on video adapters by providing the bus with a *video extension*, a 20-pin connector appended to the end of one slot in each machine. An adapter plugged into that slot can drive the built-in video interface used by the VGA on the system board. For applications in which an IBM or other compatible monitor is sufficient, this arrangement reduces the circuitry needed in the adapter; the adapter can manage the VGA's standard modes and can control the system board's video-synchronization and digital-to-analog converter (DAC) circuitry.

The video extension allows more than just the disabling of the VGA; the VGA can be configured to accept its video-input clock from the extension's DCLK input, rather than from an internally generated clock. Thus, the VGA can produce horizontal pixel counts other than the standard 640 and 720.

The video can be controlled very precisely. If the adapter drives the video extension's ESYNC line low, it controls horizontal and vertical synchronization and blanking through the HSYNC, VSYNC, and BLANK lines. An adapter can control the video DAC by driving EVIDEO low, then providing the video DAC inputs on lines P0 through P7. External clocking of the video DAC is provided separately: EDCLK enables clocking and DCLK provides the clock signal.

ERROR DIAGNOSIS

Many diagnostic features are built into the Micro Channel Architecture, including the CHCK status line, card-selected feedback line, bus-arbitration time-out recovery, and selective disabling of adapters. Full use of these features requires coordination of hardware and software. For the moment, only the hardware hooks are present; the ROM BIOS provides very little support for these features.

Adapters can use the CHCK line to signal that a serious error has occurred. The error is translated as an NMI to the processor, which queries each adapter's channel-check bit to determine which adapter was responsible for the error. A similar line exists on the PC bus, but the procedure for determining which board has caused the error is dependent on the adapter.

The Micro Channel's card-selected feedback (CD SFDBK) line is driven by an adapter whenever it responds to a memory or I/O address; the signal is latched at an I/O port on the system board. This line determines if a device is located at a given address and is functioning properly. An even more reliable method could have been designed using the system board to check for CD SFDBK and to generate an NMI if no card responded; however, this approach would adversely affect existing PC software. For example, programs expect to be able to search for video RAM by writing to an address, whether or not a video board exists at that address, and then reading it back.

Bus arbitration is also protected against certain error conditions: if a device performing a burst-mode memory transfer does not relinquish the

bus within 7.8 microseconds after another device requests preemption, then the bus is driven into the arbitrate state and forcibly removed; an NMI is also generated. I/O ports on the system board provide the arbitration level of the wayward device.

Because the locations of certain bits in the set-up registers have been standardized, system-error routines potentially can recover from many problems without crashing the system. However, this capability is not exploited in the current system software. The diagnostic features can provide specific information about hardware problems using the set-up program and POST.

BIOS CHANGES

Although a great deal of new software can be found in the PS/2 BIOS, only modest changes were made to the BIOS interface. Table 2 lists the new BIOS codes and their functions. Calls have been added to save and restore the video state, an important operation in a multitasking environment. Interrupt 15H, formerly Cassette I/O services, has been renamed System Services to reflect its plethora of uses. Calls have been added to this interrupt for the new mouse interface and for control of the POS feature. The equipment byte located at 40:10H indicates whether or not a mouse is installed. An extended BIOS data area is now allocated in high memory; it contains data for the mouse interface.

PS/2 models actually contain two versions of the BIOS. The first, called the Compatibility BIOS (CBIOS), is used by DOS 3.3; it is very similar to the BIOS in the AT and includes Cassette BASIC. The second, Advanced BIOS (ABIOS), is IBM's nod to the future. It allows access to all 16MB of address space (4GB on the Model 80) and can be used in a multitasking operating system (presumably OS/2). Perhaps IBM plans to provide OS/2 on ATs by including a new set of ROMs that perform ABIOS functions.

WEALTH OF DOCUMENTATION

In the *Technical Reference*s for the Models 50 and 60, IBM has provided the developer with a wealth of clearly organized information on PS/2 operation. The Micro Channel alone merits 107 pages of documentation, including a layout of the Micro Channel bus connector, a description of each bus signal, and timing diagrams for the bus cycles. For some functions, a logic diagram demonstrates a suggested method of implementation. The mechanical and electrical designs also are described in great detail, including recommendations for grounding, thermal cooling, and electromagnetic compatibility.

A separate section of the manual details system-board functions, including the DMA channels, timers, math coprocessor, and interrupt assignments. Another section covers the built-in I/O controllers: VGA, video DAC, keyboard, mouse, diskette, serial, parallel, and CMOS RAM. Other sections describe the power supply, keyboard, and instruction sets. One commendable addition to this manual is the section on compatibility, which includes information on the differences between devices, BIOS, and processors on the entire line of IBM products.

Non-IBM expansion options will probably be scarce until third-party suppliers have mastered the Micro Channel Architecture.

The information in the *Technical Reference*s can be supplemented with the extra-cost *BIOS Interface Technical Reference*. For $75, this single document describes software interfaces for the entire line of IBM personal computers (even the now-defunct PC*jr*). It documents each BIOS function's input, output, and processing, as well as identifying any variation in the way different models handle a function. This is fortunate, because unlike IBM's previous *Technical Reference* manuals, none of the PS/2 *Technical Reference*s provides the complete BIOS listings.

In fact, documentation for the PC and AT is different from that for the new PS/2s. The *AT Technical Reference* lacks descriptions of the bus timing and adapter interface and provides skeletal descriptions of most other system features. However, it does provide schematics and BIOS listings, so the AT really contains no undocumented interfaces. Although the PS/2 *Technical Reference*s do not have the BIOS listings, they do define interfaces to the BIOS, Micro Channel, and other hardware.

PRODUCT STRATEGY

IBM's choice of the name Micro Channel Architecture for its new bus indicates that the company finally recognizes the importance of the personal computer in its total product strategy; the term *channel* unites the personal computer with the I/O channels used on IBM mainframes; and, *architecture* indicates attention to detail and a concern for design consistency.

This newly born design cannot be considered fully developed; although the Micro Channel makes great improvements over the PC bus and shows even greater potential for increasing system performance and reliability, much of that potential can be realized only through software. The long gestation of OS/2 clearly illustrates that hardware features (such as the 80286 protected mode) are sometimes difficult for software to exploit.

A few nontechnical hurdles also may exist; non-IBM expansion options will be scarce until third-party suppliers have mastered the Micro Channel. Recognizing this problem, IBM is taking action to accelerate the process (for example, by sponsoring seminars for third-party developers). Further, the AT bus did not disappear with IBM's April announcement of the PS/2s; PC-compatible manufacturers such as Compaq have pledged their continuing allegiance to it. Although it may be a technological has-been when compared with the Micro Channel, the AT bus is still serviceable and enjoys support from thousands of vendors. Next-generation software such as OS/2 will run on AT-compatible machines, and 80386 accelerator cards can provide Model-80 power at a fraction of the cost.

The Model 80, with its 32-bit Micro Channel, lends a different perspective to the line-up; even if IBM had chosen to extend the AT bus to 32 bits and increase the speed to 10 MHz, many existing expansion cards would not operate at the higher speed. Instead of choosing an illusory compatibility with the AT bus, IBM took the opportunity to create a 32-bit bus that increases both performance and reliability. The 16-bit subset of the Micro Channel used in Models 50 and 60 provides hardware compatibility at the low end of the PS/2 line.

The PS/2 architecture represents a desirable step in the evolution of high-performance personal computers; it is a step toward smaller, faster, more reliable systems—and a step only IBM could have taken. The impact of the PS/2 line on the personal-computer market is as yet unclear, but one thing is certain: experimenting with new architectures should keep us interested for a while longer.

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No Hidden Charges. The discount prices you see on the next two pages are all you pay. We don't charge extra for UPS Ground shipping, credit cards, COD orders, purchase orders, sales tax (except Ohio) or special handling (except for non-Canadian international orders).

FACT:

Guarantees. We offer FREE 30-day no-risk return guarantees and 30-day evaluation periods on most of our products. Some dealers have no return options while others often charge restocking fees of 15% or more.

FACT:

Quality Products. Our product line consists of hundreds of high quality software development tools specifically for IBM Personal Computers and compatibles. While some dealers try to carry every software product ever written, we carry only those that meet our very high standards for quality and value.

FACT:

Latest Versions. The products we carry are the latest versions and come with the same manufacturer's technical support as if buying direct. While some dealers may participate in the software gray market, we're authorized to sell every product we carry.

FACT:

Large Inventory. We have one of the largest inventories of programmer's development products in the industry. Most orders are shipped within 24 hours. And if we don't have a product in stock, we'll get it for you fast.

FACT:

Meticulous Packaging. We'll give your shipment the extra protection needed to reach you in the best possible condition. First we'll protect your products from moisture by wrapping them in plastic. Then we'll insulate your box with high quality bubble-wrapping instead of the messy styrofoam chips that many other dealers use. Finally, we'll double-tape your box for extra strength.

FACT:

Independence. Since we're not directly affiliated with any software publisher or developer, we can give you sound, unbiased advice. Unlike some other dealers who have a special interest in promoting only certain products, we'll give you an objective look at the products we carry.

FACT:

Noncommissioned Staff. Our courteous sales staff is always ready to help you. And if you aren't sure about your needs, our knowledgeable technical staff can give you sound, objective advice. Because they are noncommissioned, you won't be pressured into making a purchase.

As you can see, we're different from the other dealers in our industry. Our customers keep coming back because we consistently provide the highest quality service and the lowest prices. So call us today and experience the differences for yourself.

PROGRAMMER'S
QUALITY INTEGRITY
Service
SUPPORT PRICE
CONNECTION

Turn the page for our product list and ordering information.

ai - expert systems

	List	Ours
1st-CLASS *by Programs in Motion*	495	399
AutoIntelligence *by IntelligenceWare*	990	739
Experteach II *by IntelligenceWare*	475	339
EXSYS *Development Software by EXSYS*	395	309
EXSYS Runtime System	600	469
Insight 1 *by Level Five Research*	95	75
Insight 2+ *byLevel Five Research*	485	379
Intelligence/Compiler *by IntelligenceWare*	990	739
Logic-Line Series *All varieties by Thunderstone*	CALL	CALL

ai - lisp language

GCLISP *Golden Common LISP by Gold Hill*	495	CALL
GCLISP 286 Developer *by Gold Hill*	1190	CALL
Microsoft LISP *Common LISP*	250	149
QNIAL *Combines LISP & APL by NIAL Systems*	CALL	CALL
TransLISP PLUS *from Solution Systems*	195	125

ai - prolog language

APT *Active Prolog Tutor from Solution Systems*	65	45
Arity Combination Package	1095	979
Expert System Development Pkg	295	229
File Interchange Toolkit	50	44
PROLOG Compiler & Interpreter	650	569
Screen Design Toolkit	50	44
SQL Development Package	295	229
Arity PRDLDG Interpreter	295	229
Arity Standard Prolog	95	77
LPA microPROLDG *All Varieties*	CALL	CALL
MPRDLDG Language Primer *LOGICWARE*	50	45
MPRDLDG P500 *by LOGICWARE*	495	395
MPRDLDG P550 *by LOGICWARE*	220	175
Prolog-86 Plus *from Solution Systems*	250	159
Turbo PROLDG *by Borland Intl*	100	63
Turbo PRDLDG Toolbox *by Borland Intl*	100	64

ai - smalltalk language

Combo Offer *by Digitalk* — *Offer ends 8/31*	200	185
Smalltalk/V	99	84
EGA/VGA Color Dption	50	45
Goodies Diskette	50	45
Smalltalk/Comm	50	42

ai - texas instruments

Arborist *Decision Tree Software* — *New*	595	519
PC Scheme *Lisp* — *New Version*	95	84
Personal Consultant Easy	495	435
Personal Consultant Images	495	435
Personal Consultant Online	995	869
Personal Consultant Plus — *New Version*	2950	2589
Personal Consultant Runtime	95	84

ada language

AdaVantage *by Meridian Software Systems* — *New*	795	739
Janus/ADA C Pak *by R&R Software*	95	84
Janus/ADA D Pak *by R&R Software*	1250	1059
Janus/ADA ED Pak *by R&R Software*	395	349

apl language

APL*PLUS/PC *by STSC*	595	424
APL*PLUS/PC Spreadsheet Mgr *by STSC*	195	139
APL*PLUS/PC Tools Vol 1 *by STSC*	295	199
APL*PLUS/PC Tools Vol 2 *by STSC*	85	58
ATLAS*GRAPHICS *by STSC*	450	329
Financial/Statistical Library *by STSC*	275	189
Pocket APL *by STSC*	95	69
STATGRAPHICS *by STSC*	795	579

assembly language

386 ASM/LINK *Cross Asm by Phar Lap*	495	389
8088 Assembler *w/Z-80 Translator by 2500 AD*	100	89
ASMLIB *Function Library by BC Assoc*	149	125
asmTREE *B-Tree Dev System by BC Assoc*	395	329
Cross Assemblers *Various by 2500 AD*	CALL	CALL
Microsoft Macro Assembler	150	93
Norton Utilities *by Peter Norton*	100	CALL
Norton Utilities (Advanced) — *New*	150	99
Turbo EDITASM *by Speedware*	99	84
Uniware Cross Assemblers *Various by SDS*	CALL	CALL
Visible Computer: 8088 *by Software Masters*	80	64
Visible Computer: 80286 — *New*	100	89

basic language

87 Software Pak *by Hauppauge*	180	149
EXIM Services Toolkit *by EXIM*	50	45
Finally *by Komputerwerks*	99	85
Inside Track *from Micro Help*	65	49
MACH 2 *by Micro Help*	69	55
MicroHelp Utilities *by MicroHelp* — *New*	59	49
Microsoft QuickBASIC — *$20 Rebate Offer*	99	63
Peeks 'n Pokes *from MicroHelp*	45	35
QBase *Relational Database by Crescent* — *New*	89	79
Quick-Tools *by BC Associates* — *New*	130	109
QuickPak *by Crescent Software*	69	59
Scientific Subroutine Library *by Peerless*	125	99
Screen Sculptor *by Software Bottling*	125	91
Stay-Res *by MicroHelp*	95	73
True Basic *w/Run-time* — *Special Price*	200	99
True Basic	100	79
Run-time Module	100	79
Various Utilities	50	41
Turbo BASIC Compiler *by Borland Intl*	100	64

blaise products

ASYNCH MANAGER *Specify C or Pascal*	175	135
C TODLS PLUS	175	135
EXEC *Program Chainer*	95	75
LIGHT TDDLS *for Datalight C* — *Special Price*	100	65
PASCAL TODLS	125	99
PASCAL TDDLS 2	100	79
PASCAL TDDLS & TDDLS 2	175	135
RUNDFF *Text Formatter*	50	45
TURBO ASYNCH PLUS	100	79
TURBD C TDDLS — *New*	129	CALL
TURBD POWER TODLS PLUS	100	79
VIEW MANAGER *Specify C or Pascal*	275	199

borland products

EUREKA *Equation Solver*	100	64
Reflex & Reflex Workshop	200	128
Reflex *Data Base System*	150	89
Reflex Workshop	70	45
Sidekick & Traveling Sidekick	125	85
Sidekick	85	57
Traveling Sidekick	70	45
Superkey	100	64
Turbo BASIC Compiler	100	64
Turbo C Compiler *(Call for support products)*	100	64
Turbo Database Toolbox	70	41
Turbo Editor Toolbox	70	41
Turbo Gameworks Toolbox	70	41
Turbo Graphix Toolbox	70	41
Turbo Jumbo Pack	300	219
Turbo Lightning	100	64
Turbo PASCAL Numerical Methods Toolbox	100	64
Turbo PASCAL and Tutor	125	85
Turbo PASCAL	100	64
Turbo Tutor	40	24
Turbo PRDLDG Compiler	100	63
Turbo PRDLDG Toolbox	100	64
Word Wizard	70	47
Word Wizard and Turbo Lightning	150	94

c++

C++ *by Guidelines w/version 1.1 kernel*	195	172
PforCe++ *Function Library by Phoenix*	395	215

c compilers

C86PLUS *by Computer Innovations*	497	359
Datalight C Compiler *by Datalight*	60	43
Datalight Developer Kit	99	74
Datalight Optimum-C	139	99
DeSmet C *w/Debugger & Large case* — *New Version*	209	184
DeSmet C *w/Debugger only* — *New Version*	159	138
Eco-C *Complete System by Ecosoft*	140	119
Lattice C Compiler *vers. 3.2 from Lattice*	500	265
MWC Let's C w/csd — *Special Price until 8/31*	125	54
Microsoft C Compiler w/CodeView	450	269
Microsoft QuickC Compiler — *New*	99	63
Turbo C Compiler *by Borland*	100	64
Uniware 68000/10/20 Cross Compiler *by SDS*	CALL	CALL

c interpreters

C-terp *by Gimpel, Specify compiler*	300	219
C Trainer *with Book by Catalytix*	122	87
Instant C *by Rational Systems*	500	369
Introducing C *by Computer Innovations*	125	99
Run/C *by Age of Reason*	120	79
Run/C Professional *by Age of Reason*	250	155

c utilities

c-tree & r-tree Combo *by FairCom*	650	518
c-tree *ISAM File Manager*	395	314
r-tree *Report Generator*	295	238
C Windows *by Syscom*	100	85
C Wings *by Syscom*	50	43
Data Windows *by Magus Inc* — *New*	CALL	CALL
dBx *dBASE to C Translator by Desktop Al*	350	299
Flash-up Windows *by Software Bottling*	90	78
GraphiC *Color version by Sci Endeavors*	350	282
GRAFLIB *by Sutrasoft*	175	159
HALO *Graphics by Media Cybernetics*	300	205
HALO Development Pkg *for Microsoft*	595	389
The HAMMER *by OES Systems*	195	129
PANEL *Forms Management by Roundhill*	295	CALL
PANEL Plus *by Roundhill*	495	CALL
PC Lint *by Gimpel Software*	139	99
PLDTHP *by Sutrasoft*	175	159
Professional C Windows *by Washburn*	89	79
Scientific Subroutine Library *by Peerless*	175	128
Vitamin C *by Creative Programming*	225	158
VC Screen *Forms Designer*	100	79
Zview *by Data Mgmt Consultants*	245	139

cobol language

CDBOLspII *by Flexus*	395	329
FPLIB *for Realia COBOL by BC Associates*	149	129
Micro Focus CDBDL *See Micro Focus Section*		
Microsoft CDBDL *See Microsoft Section*		
Realia CDBDL with RealMENU	1145	899
Realia CDBDL	995	783
RealCICS	995	783
RM/CDBDL *by Ryan-McFarland*	950	CALL
RM/COBDL 85 *by Ryan-McFarland*	1250	CALL
SCREENID *by Norcom* — *New*	400	379
screenplay *for COBOL by Flexus*	175	129

css products

Combo Package *by Custom Software Systems* — *New*	199	175
PC/SPELL *Spelling Checker* — *New*	49	45
PC/TDDLS *UNIX-like Utilities* — *New*	49	45
PC/VI *vi Editor*	149	99

debuggers & profilers

386 DEBUG *Cross Debugger by Phar Lap*	195	129
Advanced Trace-86 *by Morgan Computing*	175	115
Codesifter *Profiler by David Smith*	119	85
Codesmith-86 *by Visual Age*	145	98
DSD87 *by Soft Advances*	125	79
MiniProbe *by Atron*	395	369
Periscope I *with Board by Periscope*	345	289
Periscope II *with NMI Breakout Switch*	175	139
Periscope II-X *Software only*	145	105
Periscope III *8 MHz version*	995	824
Periscope III *10 MHz version*	1095	899
The PRDFILER *with Source Code by DWB*	125	89
TURBDsmith *Source debugger for Turbo Pascal*	69	59
The WATCHER *Profiler by Stony Brook*	60	51

disk utilities

Back-It *by Gazelle Systems* — *New*	100	89
Disk Optimizer *by Softlogic Systems*	60	55
FASTBACK *by 5th Generation Systems*	179	129
XenoCopy-PC *by XenoSoft* — *New*	80	69

dos utilities

Command Plus *by ESP Software*	80	69
FANSI-CDNSDLE *by Hersey Micro*	75	62
Norton Commander *by Peter Norton*	75	CALL
OPAL *Shell Language by Software Factory* — *New*	99	89
Q-DDS II *by Gazelle Systems* — *New*	70	59
Taskview *by Sunny Hill Software*	80	55

essential products

C Utility Library	185	119
Essential Comm Library *with Debugger*	250	189
Essential Comm Library *Software Only*	185	125
Breakout Debugger Dnly *Any language*	125	89
Essential Graphics	250	183

forth language

CFDRTH *Native Code Compiler by LMI*	300	229
Forth/83 Metacompiler *Specify Target*	750	599
PC/Forth *by Laboratory Microsystems*	150	109
PC/Forth+ *by Laboratory Microsystems*	250	199
Advanced Color Graphics Support	100	74
Enhanced Graphics Support	200	148
Intel 8087 Support	100	74
Interactive Symbolic Debugger	100	74
Native Code Optimizer	100	74
Software Floating Point	100	74
UR/Forth *by LMI*	350	279
Object Module Libraries	500	395

fortran language

50 MDRE: FDRTRAN *by Peerless Engr*	125	95
ACS Time Series *by Alpha Computer Service*	495	389
Essential Graphics *by Essential Software*	250	183
Forlib-Plus *by Alpha Computer Service*	70	44
FORTLIB *by Sutrasoft*	125	109
FDRTRAN Addendum *by Impulse Engr*	95	85
FORTRAN Addenda *by Impulse Engr*	165	138
GRAFLIB *by Sutrasoft*	175	159
HALD *Graphics by Media Cybernetics*	300	205
I/D PRD *by MEF Environmental*	149	129
Microcompatibles Combo Package	240	215
Grafmatic	135	117
Plotmatic	135	117
Microsoft FDRTRAN *w/CodeView*	450	269
No Limit *by MEF Environmental*	129	109
Numerical Analyst *by MAGUS*	295	249
PANEL *by Roundhill Computer Systems*	295	CALL
PLOTHP *by Sutrasoft*	175	159
RM/FORTRAN *by Ryan-McFarland*	595	CALL
RTC PLUS *Fortran to C by Cobalt Blue*	450	399
Scientific Subroutine Lib *by Peerless*	175	128
Statistician *by Alpha Computer Service*	295	235
Statlib.GL: *by PSI/Systems*	295	239
Statlib.TSF: *by PSI/Systems*	295	239
Strings & Things *by Alpha Computer Service*	70	45

greenleaf products

Greenleaf Comm Library	185	125
Greenleaf Data Windows Library	225	155
with Source Code	395	249
Greenleaf Functions	185	125

help utilities

HELP/Control *by MDS*	125	99
On-line Help *from Opt-Tech*	149	99
SoftScreen/HELP *by Dialectic Systems*	195	149

lattice products

Lattice C Compiler *ver 3.2 from Lattice*	500	265
with Library Source Code	900	495
C Cross Reference Generator	50	37
with Source Code	200	139
C-Food Smorgasbord *Function Library*	150	95
with Source Code	300	179
C-Sprite *Source Level Debugger*	175	119
Curses *Screen Manager*	125	85
with Source Code	250	169
dBC *Specify dBC II or dBC III*	250	169
with Source Code	500	356
dBC III Plus	750	594
with Source Code	1500	1184
LMK *Make Facility*	195	138
RPG II Combo *All three items below*	1100	875
RPG II Compiler *No Royalties*	750	625
RPG II SEU *Screen Entry Utility*	250	199
RPG II Sort/Merge	250	199
RPG II Screen Design Aid Utility	350	309
SecretDisk *File Encryption Utility*	120	88
SideTalk *Resident Communications*	120	88
SSP/PC *Scientific Subroutine Library*	350	269
Text Management Utilities	120	88
TopView Toolbasket *Function Library*	250	178
with Source Code	500	356

metagraphics products

LightWINDOW/C *for Datalight C*	95	79
FontWINDDW	95	79
FontWINDOW/PLUS	275	229
MetaWINDOW *No Royalties*	195	159
MetaWINDDW/PLUS	275	229
TurboWINDDW/C *for Turbo C*	95	79
TurboWINDOW/Pascal *for Turbo Pascal*	95	79

micro focus products

Micro Focus Level II CDBOL *w/Animator*	495	395
Level II COBDL	349	279
Level II Animator	195	155
Micro Focus Level II COBOL/ET for UNIX	CALL	CALL
Micro Focus Personal CDBDL	149	119
Micro Focus Professional COBDL	2000	1595
Micro Focus VS CDBDL/XENIX	1495	1195
Micro Focus Support Products:		
COBOL/IQ *Ad hoc Report Writer*	495	395
COBOL/IQ *for DOS 3.X Networks*	995	795
FDRMS-2	295	235
SDURCEWRITER	995	795

microport products

System V/386 Combination *New*	799	699
386 Runtime System *New*	299	259
386 Software Development System *New*	399	349
Text Preparation System *New*	199	169
386 Unlimited License Kit *New*	299	259
DOSMerge386 *Run DOS and UNIX together* *New*	CALL	CALL
System V/AT Combination	549	465
AT Runtime System	199	169
AT Software Development System	249	209
Text Preparation System	199	169
AT Unlimited License Kit	249	209
OOSMerge286 *Run DOS and UNIX together* *New*	149	125

microsoft products

Microsoft BASIC Compiler *for XENIX* *New*	695	419
Microsoft BASIC Interpreter *for XENIX*	350	209
Microsoft C Compiler *with CodeView*	450	269
Microsoft COBOL Compiler *with COBOL Tools*	700	429
for XENIX	995	609
Microsoft FORTRAN *Optimizing Compiler/CodeView*	450	269
Microsoft FORTRAN *for XENIX*	695	419
Microsoft Learning DOS	50	36
Microsoft LISP *Common LISP*	250	149
Microsoft MACH 10 *with Mouse & Windows*	549	369
Microsoft MACH 10 *Board only*	399	279
Microsoft Macro Assembler	150	93
Microsoft Mouse *Bus Version*	175	114
Microsoft Mouse *Serial Version*	195	124
Microsoft muMath *Includes muSIMP*	300	179
Microsoft Pascal Compiler	300	179
for XENIX	695	419
Microsoft QuickBASIC *$20 Rebate Offer*	99	63
Microsoft QuickC *New*	99	63
Microsoft Sort	195	125
Microsoft Windows	99	63
Microsoft Windows Development Kit	500	299
Microsoft Word	450	269

modula-2 language

EXE2LNK *MASM Interface by PMI* *New*	49	45
Macro2 *Macro preprocessor by PMI* *New*	89	79
ModBase *by PMI* *New*	89	79
MODULA-2 Apprentice Pkg by LOGITECH	99	79
MODULA-2 Magic Pkg by LOGITECH	99	79
MODULA-2 ROM Pkg & Cross RT Debugger	299	239
MODULA-2 Window Pkg by LOGITECH	49	39
MODULA-2 Wizard's Pkg by LOGITECH	199	159
Repertoire *by PMI*	89	74

mouse products

LOGIMOUSE BUS *with PLUS Pkg by LOGITECH*	119	98
with PLUS & PC Paintbrush	149	119
with PLUS & CAD Software	189	153
with PLUS & CAD & Paint	219	179
LOGIMOUSE C7 *with PLUS Pkg. Specify Connector*	119	98
with PLUS & PC Paintbrush	149	119
with PLUS & CAD Software	189	153
with PLUS & CAD & Paint	219	179
Microsoft Mouse *Bus Version*	175	114
Microsoft Mouse *Serial Version*	195	124

other languages

ACTOR *by Whitewater Group* *New*	495	419
CCS MUMPS *Single-User by MGlobal*	60	50
CCS MUMPS *Single-User Multi-Tasking*	150	129
CCS MUMPS *Multi-User*	450	359
Marshal Pascal *by Marshal Language Systems*	189	155
Pascal-2 *by Oregon Software* *New*	395	325
Personal REXX *by Mansfield Software*	125	99
SNOBOL4+ *by Catspaw*	95	80

other products

Dan Bricklin's Demo Pgm *by Software Garden*	75	57
Dan Bricklin's Demo Tutorial	50	45
Fast Forward *by Mark Williams* *New*	70	59
Informix *All Varieties by Informix*	CALL	CALL
Instant Replay *by Nostradamus*	150	CALL
MKS Toolkit *w/vi Editor by MKS* *New Version*	139	114
MicroTEX *Typesetting from Addison Wesley* *New*	295	CALL
Net-Tools *by BC Associates*	149	129
OPT-Tech Sort *by Opt-Tech Data Proc*	149	99
PC/TOOLS *by Custom Software*	49	45
Screen Machine *by MicroHelp*	79	59

phoenix products

Pasm86 *Macro Assembler version 2.0*	195	108
Pdisk *Hard Disk & Backup Utility*	145	89
Pfantasy Pac *Phoenix Combo*	995	599
Pfinish *Execution Profiler*	395	225
Pfix86plus *Symbolic Debugger*	395	225
PforCe *Specify C Compiler*	395	209
PforCe++ *Specify C Compiler and C++*	395	215
Plink86plus *Overlay Linker*	495	279
Pmaker *Make Utility*	125	78
Pmate *Macro Text Editor*	195	108
Pre-C *Lint Utility*	295	154
Ptel *Binary File Transfer Program*	195	108

polytron products

PolyBoost *The Software Accelerator*	80	64
PolyDesk III	99	72
PolyDesk III Archivist	50	42
PolyDesk III Cryptographer	50	42
PolyDesk III Talk	70	52
PolyLibrarian *Library Manager*	99	73
PolyLibrarian II *Library Manager*	149	109
PolyMake *UNIX-like Make Facility*	149	109
PolyShell	149	109
Polytron C Beautifier	50	42
Polytron C Library I	99	72
Polytron PowerCom *Communications*	139	105
PolyXREF *Complete Cross Ref Utility*	219	169
PolyXREF *One language only*	129	99
PVCS Corporate *Version Control System*	395	309
PVCS Personal	149	109
PVMFM *Polytron Virtual Memory File Mgr*	199	155

program mgmt utilities

Interactive EASYFLOW *by Haventree*	150	125
PrintQ *by Software Directions*	89	84
Quilt Computing Combo Package	250	199
QMake *Program Rebuild Utility*	99	79
SRMS *Software Revision Mgmt System*	185	159
Source Print *by Aldebaran Labs* *New Version*	97	75
TLIB *by Burton Systems Software*	100	89
Tree Diagrammer *by Aldebaran Labs* *New Version*	77	67

raima products

dbQUERY *Single-User Query Utility*	195	129
Single-User with Source Code	495	389
Multi-User	495	389
Multi-User with Source Code	990	699
dbVISTA *Single-User DBMS*	195	129
Single-User with Source Code	495	389
Multi-User	495	389
Multi-User with Source Code	990	699

sco products

Complete XENIX System V *by SCO*	1295	994
Development System	595	499
Operating System *Specify XT or AT*	595	499
Text Processing Package	195	144
Lyrix *by SCO*	595	449
SCO Professional *1-2-3 Workalike for XENIX*	795	595
SCO XENIX-NET £	595	495

softcraft products

Btrieve *ISAM Mgr with No Royalties*	245	184
Xtrieve *Query Utility*	245	184
Report Option *for Xtrieve*	145	99
Btrieve/N *for Networks*	595	454
Xtrieve/N	595	454
Report Option/N *for Xtrieve/N*	345	269

text editors

Brief & dBrief Combo *from Solution Systems*	275	CALL
Brief	195	CALL
dBrief *Customizes Brief for dBASE III*	95	CALL
Epsilon *Emacs-like editor by Lugaru*	195	147
KEDIT *by Mansfield Software*	125	98
Micro/SPF *by Phaser Systems*	175	139
Microsoft Word	450	269
PC/VI *by Custom Software Systems*	149	99
SPF/PC *by Command Technology Corp*	CALL	CALL
Vedit *by CompuView*	150	98
Vedit Plus *by CompuView*	185	128

turbo pascal utilities

ALICE *Interpreter by Software Channels*	95	66
DOS/BIOS & Mouse Tools *by Quinn-Curtis*	75	67
Flash-up Windows *by Software Bottling*	90	78
MACH 2 *for Turbo Pascal by Micro Help*	69	55
MetraByte D/A Tools *by Quinn-Curtis*	100	89
Science & Engrg Tools *by Quinn-Curtis*	75	67
Screen Sculptor *by Software Bottling*	125	91
Speed Screen *by Software Bottling*	35	32
System Builder *by Royal American*	150	129
IMPEX *Query Utility*	100	89
Report Builder	130	115
TDebugPLUS *by TurboPower Software*	60	49
Turbo EXTENDER *by TurboPower Software*	85	64
Turbo OPTIMIZER *by TurboPower* *New*	75	65
Turbo OPTIMIZER *with Source Code* *New*	125	108
Turbo Professional *by Sunny Hill*	70	45
Turbo.ASM *by BC Associates* *New*	100	84
TurboHALO *from IMSI*	129	98
TurboPower Utilities *by TurboPower*	95	78
TurboRef *by Gracon Services*	50	45
TURBOsmith *Source Debugger by Visual Age*	69	59
Universal Graphics Library *by Quinn-Curtis* *New*	150	119

wendin products

Operating System Toolbox	99	79
PCNX *Operating system*	99	79
PCVMS *Similar to VAX/VMS*	99	79
Wendin-DOS *Multitasking DOS* *New*	99	85
XTC *Text Editor w/Pascal source*	99	75

xenix/unix products

Btrieve *ISAM File Mgr by SoftCraft*	595	454
C-terp *by Gimpel, Specify compiler*	498	379
c-tree *ISAM Mgr by FairCom*	395	314
dBx *with Library Source by Desktop AI*	550	489
OOSIX *Console Version by Data Basics*	399	349
OOSIX *User Version by Data Basics*	199	179
Informix *All Varieties by Informix*	CALL	CALL
Micro Focus Products *See Micro Focus Section*		
Microport Products *See Microport Section*		
Microsoft Products *See Microsoft Section*		
PANEL Plus *by Roundhill Computer Systems*	495	CALL
REAL-TOOLS *Binary Version by PCT*	149	89
Library Source Version	399	289
Complete Source Version	499	369
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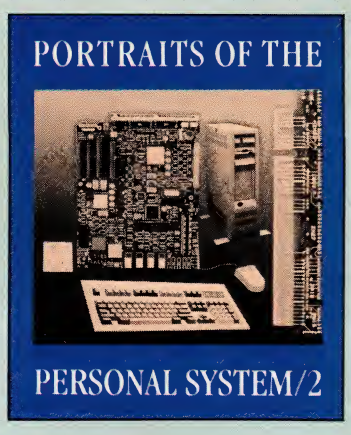
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VGA: Evolutionary Half-Step

JOHN T. COCKERHAM

The new graphics standard for the PS/2s continues IBM's slow march toward graphics maturity.

Just when a giant step was needed, IBM has taken a half-step in the evolution of graphics subsystems for personal computers. The Personal System/2 Models 50, 60, and 80 sport a new built-in graphics standard called the Video Graphics Array (VGA). The Model 30 uses a subset of the VGA called the Multi-Color Graphics Array, or MCGA (see the accompanying sidebar, "Model 30 Graphics").

Those hoping for a dramatic advancement in the state of computer graphics will not be satisfied with the VGA. At best it is a repackaged Enhanced Graphics Adapter (EGA) with slightly better resolution and a few bugs worked out. The VGA provides a maximum resolution of 640 horizontal by 480 vertical pixels with 16 colors. It has a new low-resolution mode of 320-by-200 pixels with 256 colors drawn from a palette of more than 256,000 colors. Unlike the EGA, the VGA and its associated circuitry is contained on the system board (photo 1).

The VGA's capabilities have been limited in part by IBM's efforts to provide compatibility with its predecessor, the EGA. The VGA has many attributes of the EGA; any EGA programmer should feel instantly at ease with the VGA (and, unlike the EGA, the documentation is understandable). Although this compatibility with existing applications is of paramount concern to software developers and users, equally important is how well the new standard corrects the inadequate performance of its predecessors—and how well it provides for the industry's need for more graphics functionality.

In what is clearly a move to establish the VGA as a standard across its existing PC product line, IBM also has introduced a board called the PS/2 Display Adapter that incorporates the VGA into the PC-style bus (photo 2). In addition, IBM has announced a separate high-performance display adapter, the 8514/A, that provides extended display features and on-board support for applications demanding high-resolution graphics (photo 3). The 8514/A connects directly to the monitor without using the circuitry on the system board.

At its maximum resolution, the 8514/A produces graphics displays of 1,024-by-768 pixels, designed for the rapidly growing workstation market. IBM's Professional Graphics Controller (PGC) has been IBM's only previous attempt to provide a graphics product for PC-based computer-aided design (CAD) packages, but it has not caught on in overwhelming fashion.

INTERCHANGEABLE DISPLAYS

Along with the new graphics subsystems, IBM introduced four monitors: the 8503, 8512, 8513, and 8514 (see table 1). All four monitors are interchangeable among the various PS/2 models, and all can handle VGA display modes with a maximum resolution of 640-by-480.

The large number of colors available with the VGA dictated the use of analog technology for the video system. A transistor-transistor logic (TTL) monitor with 256,000 colors would have required 18 color lines—that is, 6 each for red, green, and blue—on the display in addition to various other control signals.

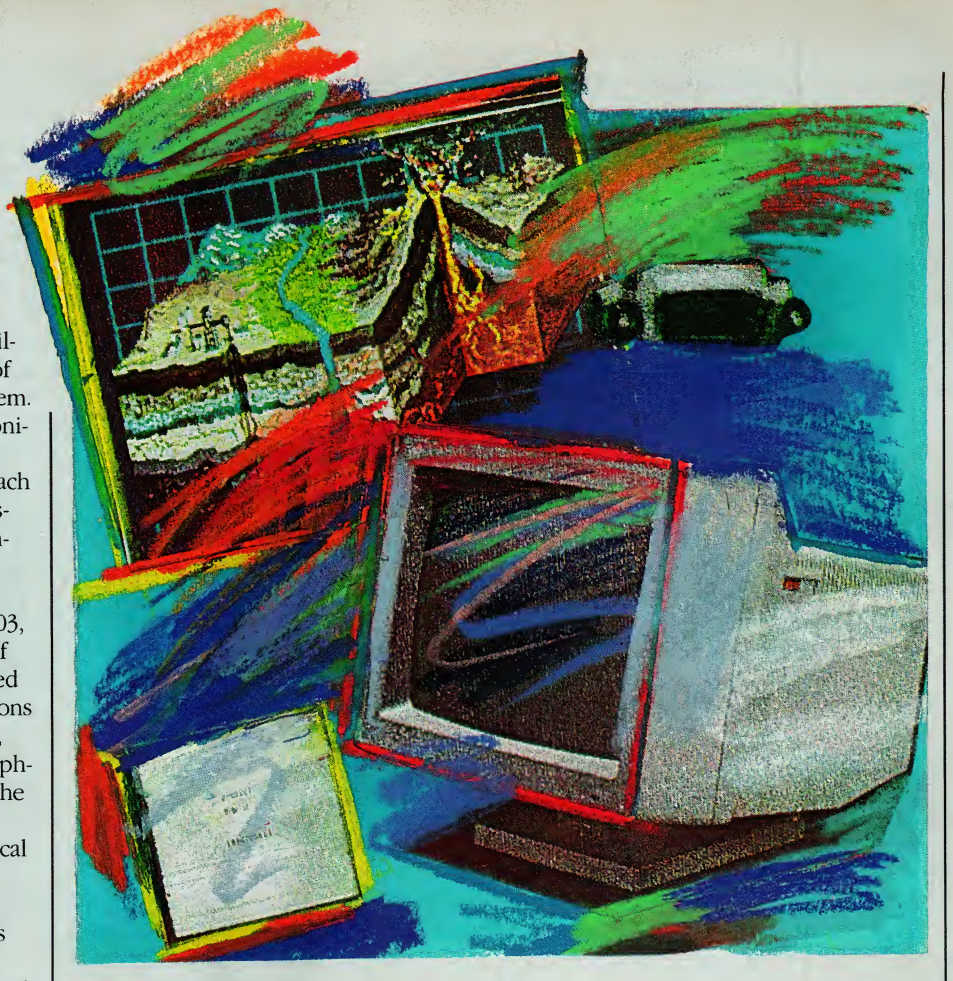
The lone monochrome offering amoung the group is the 12-inch 8503, which can display up to 64 shades of gray (see photo 4). Although intended for low-end text-processing applications with minimal graphics requirements, the 8503 has acceptable text and graphics quality and, when coupled with the 8514/A graphics adapter, will allow gray-scale applications, such as medical image processing, to be developed.

The 8512 and 8513 are middle-level color analog monitors. The less expensive 8512 measures 14 inches and has a stripe pixel arrangement with a pitch of 0.41 millimeter (see photo 5). The 8513 is 12 inches (see photo 6); although it has a smaller screen size, it produces a clearer picture with a shadowmask pitch of 0.28 mm.

The 16-inch 8514 monitor is designed for heavy graphics use that requires high resolution (see photo 7). A maximum resolution of 1,024-by-768 pixels is possible. The 8514 monitor has a phosphor dot pitch of 0.31 mm, which produces an excellent, clear display. Although any PS/2 graphics subsystem can drive this monitor, it is most effective when mated with the 8514/A adapter.

The new analog monitors are incompatible with all existing PC graphics adapters. However, the user with an adaptable-sync monitor that has an analog mode (such as the NEC MultiSync) can attach it to a PS/2 machine by replacing the cable to match the new signal assignments and to identify the monitor to the video hardware. In addition, several vendors have announced VGA-compatible monitors.

Because Models 60 and 80 are floor-standing units, the monitor for these systems must sit directly on the desktop or on a stand rather than in its customary position on top of the system unit. Although IBM researched what monitor height would minimize neck strain, prevailing sentiment so far seems to be that the monitors are too low, even with their stands. A tilt/swivel-base stand comes standard with the 8503, 8513, and 8514 monitors; it is available as an option on the 8512.



Other ergonomics concerns include the monitors' refresh rate and pixel formatting; both affect the user's perception of the picture. A slow refresh rate and harsh pixel formatting contribute to operator fatigue and can cause double vision and headache. For flicker-free operation, each of the new monitors has a video bandwidth of up to 28.5 MHz, which in 480-vertical-line modes translates to 70-Hz screen refresh, well above the human threshold for sensing flicker. Screen size also can affect visual comfort.

BIOS COLOR MODES

To complement the new display hardware, IBM has added three BIOS display modes: 11H, 12H, and 13H (see table 2). All the new modes choose their colors from a set of more than 256,000 colors. As a welcome relief to all those programmers who struggled with the two-way split of scan lines in the CGA, the new modes have a linear organization. Figure 1 shows the display RAM layout for modes 11H and 12H; figure 2, for mode 13H.

Mode 11H (17 decimal), supported by both the VGA and the MCGA, is a two-color graphics mode with a resolution of 640-by-480 (see photo 8). The video page is located at real address 0A0000H; a pixel is represented as one bit from left to right within each byte; scan lines are organized linearly throughout the display RAM.

Mode 12H (18 decimal) offers 16 colors with a resolution of 640-by-480. It is supported by only the VGA and the 8514/A. This mode uses one bit from each of four parallel bit planes to specify color. Again, a pixel is represented as one bit from left to right within each byte, with the scan lines organized linearly beginning at real address 0A0000H.

Mode 13H (19 decimal), supported by the VGA, MCGA, and 8514/A, is the sensational 256-color mode with 320-by-200 resolution (see photo 9). This mode is double-scanned on the display—that is, every video line is painted twice on the screen, one beneath the other, before the pixel data for the next line are painted. The display memory is organized as one pixel per byte in a linear addressing scheme starting from real address 0A0000H.

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HEART OF THE GRAPHICS SYSTEM

The graphics subsystem on the Models 50, 60, and 80 consists of the VGA, the digital-to-analog converter (DAC), and the external video connector, all located on the system board as shown in photo 1. The VGA provides all of the control signals for the CRT; the DAC converts the VGA's digital color specifications into analog signals for the CRT; and the external video connector provides a route for an external display adapter that directly hooks up to the DAC. When a board is in this slot, the PS/2's new Micro Channel bus can route the signals of the external display adapter to the DAC, shutting off the VGA. The use of this routing is optional; an adapter board is free to provide its own monitor connection through the adapter mounting bracket.

The DAC (INMOS G171) on every PS/2 generates the dazzling colors for the analog displays, expanding the palette to 256,000 colors and displaying up to 256 at one time. The DAC's high-performance color look-up table translates the digital color selections to analog red-green-blue (RGB) output. The device maps eight digital output lines from the display controller into the 256 colors that can be active at one time. Each color is represented by six bits for each RGB analog output, yielding a total of $2^{(3 * 6)}$, or 262,144 colors. The VGA's color selection is more than adequate for three-dimensional shading in CAD/CAM applications; however, in high-resolution modes where only 16 simultaneous colors are permitted, the visual impact is lessened.

VGA MAKEUP

The VGA chip itself has four major sections: the CRT controller (CRTC), the graphics-data controller (GDC), the sequencer, and the attribute controller (ATC). The VGA's CRTC is a renovated version from the EGA; the vertical and horizontal timings are different, more vertical lines are available, and the vertical retrace interrupt now works. Under the EGA, hardware I/O instructions directly manipulate the cursor's appearance; under the VGA, the I/O instructions do not produce the same results on the screen and may need modification. For example, the cursor disappears if the VGA's CRTC attempts to display it as two separated pixel blocks in the text-character cell.

To assist with animation and scrolling applications, the VGA CRTC can interrupt the CPU on interrupt-request (IRQ) line 2 at the start of vertical retrace. By using this interrupt to update the screen image or to change the scroll state, programs do not have to wait for retrace events by looping on the VGA status registers. Whereas the EGA could not reliably report an interrupt state, in the VGA CRTC a latch correctly indicates the state of the interrupt (see "The EGA's Vertical Interrupt Status Bit," Michael Abrash and Dan Illowsky, August 1986, p. 130).

To increase the VGA's potential vertical resolution, the CRTC has 10 bits for the vertical registers, allowing the VGA to display up to 1,024 vertical lines. The EGA is limited to 512 vertical lines. The EGA, however, is unlimited in its horizontal dimension because its horizontal size is specified in character units rather than pixel units. Because each character specifies up to 8 pixels in the VGA, the maximum VGA horizontal dimension is about 2,000 pixels.

The GDC provides rudimentary pixel handling for four parallel bit planes, operating on the planes simultaneously. Most functions of the EGA's GDC have been preserved in the VGA. However, the EGA's little used GDC position registers, which determine the bit planes that are controlled by the GDC, have been eliminated.

When the VGA operates in graphics modes, the program must paint any text information on the screen pixel by pixel. In writing modes, the GDC allows up to eight pixels to be drawn at one time to facilitate drawing text characters. (For more about writing modes, see "Pixel Alignment of EGA Fonts," Programming Practices, John T. Cockerham, January 1987, p. 165.)

The VGA sequencer arbitrates accesses to display RAM and to the fonts. It sequencer allows up to eight fonts compared with four in the EGA. Like

MODEL 30 GRAPHICS

Although its name and market position on the low-end Model 30 are similar to the Color Graphics Adapter (CGA), the Multi-Color Graphics Array (MCGA) is actually a subset of the Video Graphics Array (VGA). Like the VGA, it is built into the system board; it displays up to 256 colors from a potential 256,000 colors.

The MCGA and the VGA differ in availability of display modes, physical components, and I/O programming interface; the BIOS interface, digital-to-analog converter (DAC), soft fonts, and displays are common to the two systems. The MCGA can drive all of the analog displays of the PS/2 line; like the VGA, at power-up the video subsystem senses the monitor's type and configures itself accordingly.

For most functions, the MCGA BIOS calls duplicate the VGA's. Although it indicates an error whenever the MCGA cannot perform the desired function, the BIOS masks most of the hardware differences between the MCGA and other display adapters.

The MCGA operates only in a restrictive set of established BIOS video modes. The hardware does not support the VGA's 16-color video modes, 0DH (320-by-200), 0EH (640-by-200), 10H (640-by-350), and 12H (640-by-480). Calls to set a VGA-type internal palette are also ignored.

The MCGA circuitry differs from both the VGA and the CGA; it consists of two gate arrays located on the system board. The I/O interface is somewhat similar to the CGA's, and extra graphics memory accommodates additional graphics modes.

The MCGA has two distinct pages of display RAM: one 32KB page is located at real address B8000H (the BIOS color text page); the other, a 64KB page, is addressed at A0000H (the BIOS high-resolution graphics page). The 64KB page is populated with special, dual-ported video RAM (VRAM) chips: one for rapid sequential access and the other for random access. These special VRAM chips are needed because in BIOS mode 13H (320-by-200, 256 colors), the video hardware must retrieve a byte from the display buffer every 230 nanoseconds in order to display one pixel's color on the screen. The CPU uses the random access port when accessing VRAM.

To preserve tradition, the register set of the MCGA's CRT controller (CRTC) is modeled after the Motorola 6845 CRTC. However, the new MCGA uses different values for the horizontal and vertical registers than does the CGA; drivers written for the CGA do not execute properly if they bypass the BIOS and program registers; they have to be rewritten. To prevent BIOS bypass, IBM added a mode-control bit to the MCGA to lock the horizontal and vertical registers; the BIOS sets this control bit after every mode

the EGA, the VGA displays only two fonts at any one time.

The ATC sets up the color assignment and translates it to pixels on the screen. The ATC also interprets the attribute byte in text modes and provides the extra blank pixel required by the new nine-dot-wide fonts.

The VGA's ATC supports horizontal panning of the screen in all of the new graphics modes. The EGA has a bug in its horizontal panning logic; panning with a split screen causes the first character of the split screen to scroll off to the left, which is visually unappealing. In the VGA, the bug is still present, but a bit in the ATC allows the user to turn it on and off at will.

To support multitasking, the ATC sets the VGA's digital 64-color spectrum to specific portions of the DAC's 256-color palette, allocating a portion of the DAC's palette to each display context. During a context exchange, the user can designate the context's portion of the DAC palette in one I/O instruction, thus saving a lengthy reload of the DAC palette. The ATC now decodes byte I/O writes only at address 3C0H. Applications using word OUTs (OUT DX, AX) need to be modified.

HARDWARE DIFFERENCES

One design goal for operating systems is to be able to switch rapidly from one screen, or *display context*, to another. The VGA preserves the display context, important to achieving that goal. All VGA registers are read-write, but not all portions of the VGA state are accessible, which complicates video-state preservation. A program cannot directly access the GDC latches, intermediate value registers for the planes used during pixel operations. Instead, the program preserves the planes by writing them into the VGA's display RAM and then reading them out one plane at a time, destroying in the process whatever data were already present in the display RAM.

In addition, the VGA cannot preserve the flip-flop in the ATC, which determines whether the next OUT addressed to the ATC is address or data. If an interrupt were to result in a video-state exchange, when the context resumed execution the flip-flop would be in an unknown—and possibly wrong—state. Even under a single-threaded executive such as DOS, the mouse driver could alter the ATC. Therefore, programs that directly address the VGA ATC must disable interrupts while doing so (the Model 50 BIOS does exactly that).

To accommodate a second graphics adapter, the VGA can effectively separate itself from the CPU by disabling I/O register decoding and display RAM access. When this mode is set, the VGA continues to operate a display if left in a display mode; the EGA does not have this capability.

BIOS CHORES

Unlike the EGA BIOS, which is located on the EGA itself, the VGA BIOS is part of the system BIOS because the VGA is integrated into the system board. To keep the BIOS compatible with the previous generation of graphics adapters, IBM preserved the BIOS standards set in the PC. Video services are still accessed through interrupt 10H, and the display buffer layout for any BIOS mode is identical across the PC and PS/2 families.

The BIOS performs housekeeping functions at power-up, such as determining the primary display. The BIOS senses which type of monitor is attached to the system and configures accordingly. The BIOS then sends the programmer information about the capabilities of the active display, including a roster of the available BIOS modes, the cell size of screen characters, and monitor information.

The BIOS contains the raw pixel images for different fonts. In addition to the 8-by-8-pixel double dot and the 8-by-14-pixel font, a new 9-by-16-pixel font takes advantage of the VGA's increased vertical resolution. Compared with the 8-by-14-pixel font, the glyphs have changed little, except for a dot placed in the middle of the zero instead of a slash through the character.

All of the 80-column text modes operate with a horizontal resolution of 720 pixels, making each glyph 9 pixels

change. Therefore, unless the application is written specifically for the MCGA, it cannot bypass the BIOS in order to set the hardware.

Like the VGA (but unlike the CGA), the MCGA can issue interrupts during vertical retrace. At CRTC index 11H, the read-write interrupt-control register permits the MCGA to issue an interrupt request on IRQ2 upon vertical retrace. Reading this register reflects the state of the interrupt.

To maintain compatibility outside of the CRTC, the other CGA registers have been incorporated unchanged into the MCGA, including the CGA mode-control register (3D8H), the status register (3DAH), and the color-select register (3D9H, and now called the CGA border-control register). However, the interpretation of the colors selected by the CGA border-control register has been modified to reflect the presence of the DAC palette. This register selects the background color palette for BIOS modes 4, 5, 6, and 11. The programmer is free to change the colors in these modes to suit the application by simply changing one of the first 16 entries of the DAC palette.

The MCGA allows soft fonts in which the programmer can change the pixel images for the characters. The EGA, but not the CGA, includes this feature. The BIOS loads the appropriate font out of its ROM and into font memory upon display mode changes. The fonts are organized as a sequential row of scan lines in memory similar to the VGA and the EGA. When the programmer activates alternate font addressing, the MCGA remaps one bit of the attribute byte of each character to select the font, allowing the MCGA to display up to 512 characters. This soft font feature is implemented across all the PS/2 models. In the MCGA, only four fonts can be in memory at any time; and, like the VGA and the EGA, only two fonts can be active at one time.

The MCGA must drive a 28-MHz monitor system. Despite the relatively low performance of the 8086 CPU in the Model 30, contention can exist for the video-display buffer, which is manifested by wait states before accesses to display RAM. However, only between five and seven wait states are needed, depending on the mode.

Although the MCGA is considered a low-performance graphics subsystem, it provides medium-resolution graphics on PS/2 displays. The 640-by-480, 2-color mode should be adequate for standard graphics applications in the office or classroom. However, the MCGA's chip count is higher than the VGA's and it uses more expensive components. The duplicated research and development costs alone would have justified placing the VGA on the Model 30.

—John T. Cockerham

wide. The ninth pixel is blank except for the ASCII graphical elements (character codes C0H through DFH); the ATC replicates the eighth pixel into the ninth. The VGA also assigns active duty to mode 3, which had reserved status on the EGA. The VGA defines it as a 720-by-400, 16-color text mode.

The VGA also supports the EGA digital palette, which is now called the *internal palette*. The digital output of the internal palette (any of 64 colors) is mapped into the VGA's *analog palette*, which provides the colors displayed on the screen. BIOS calls maintain both of these palettes.

For complete color compatibility with EGA applications, the analog palette must be arranged properly. For 16-color modes, the BIOS loads the complete 64-color spectrum of the EGA's palette into the analog palette.

In order to support the monochrome display transparently, the BIOS uses a mechanism called *gray-scale summing* for mapping color to a monochrome screen; the BIOS passes through the analog palette and rewrites the red, green, and blue components using the following formula:

palette value = 30% red + 59% green + 11% blue

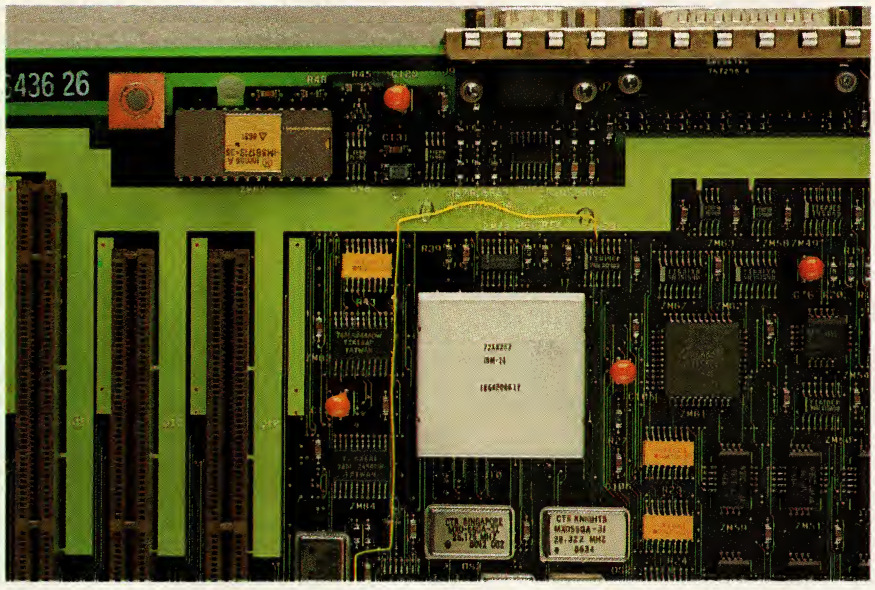
This provides a consistent mapping from color to 64 gray shades. The 16-color modes can display only 16 gray shades at any one time. The 64-gray-shade mode is available only within the 256-color mode.

For EGA compatibility, the save-area functions are still present in the BIOS; the save area provides the programmer with a way to capture palette data. For multitasking, the BIOS also provides a function to save all of the pertinent VGA I/O registers into a video-state buffer.

In the VGA BIOS, the cursor-appearance logic is slightly different from the EGA in order to accommodate the change in the cursor's hardware implementation. The user must choose between two options: one uses the old CGA line-numbering scheme; the other uses the new VGA numbering scheme. Programs that change the shape of the cursor for user feedback must be modified to incorporate a limitation of the cursors.

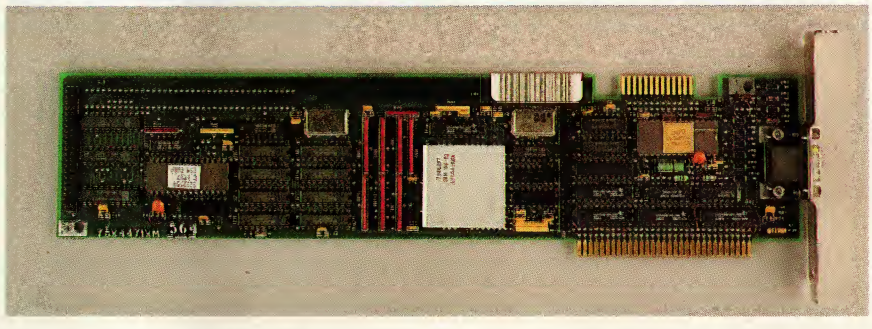
The VGA BIOS lets programs know when a request has been successfully completed by changing the contents of the registers upon return. The BIOS also has new functions to change the DAC palette, as well as new fonts to take advantage of the increased

PHOTO 1: *VGA Graphics Subsystem*



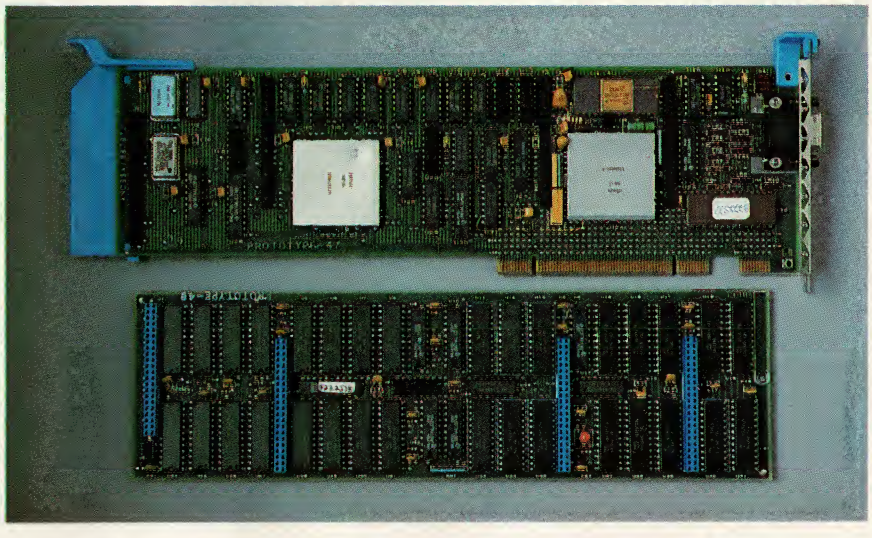
IBM has integrated the VGA and its associated circuitry onto the system board. The VGA is the large silver-cased chip. The DAC is the ceramic gold-capped chip near the expansion slots. The 15-pin video connector is near the video circuitry.

PHOTO 2: *PS/2 Display Adapter*



IBM offers the PS/2 Display Adapter, with a PC-style bus, that can be installed in the Model 30 or any member of the PC family to provide VGA capabilities.

PHOTO 3: *8514/A Display Adapter and Memory Expansion Kit*



The maximum resolution of the 8514/A Display Adapter (top), when equipped with the optional 8514 Memory Expansion Kit (bottom), is 1,024-by-1,024.

PHOTO 4: *8503 Monochrome Monitor*

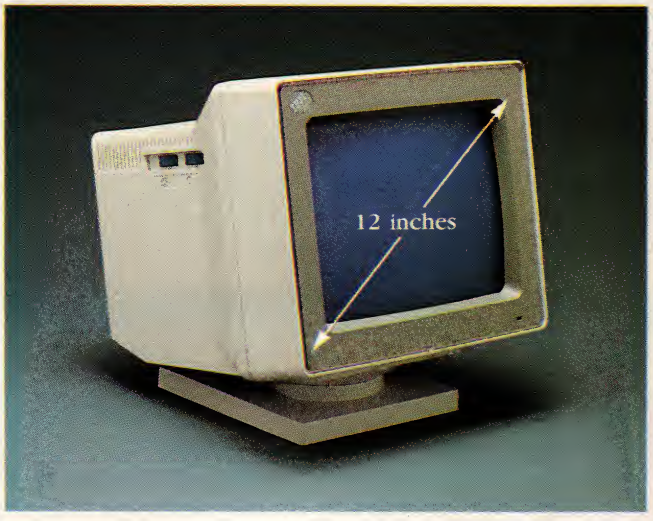


PHOTO 5: *8512 Color Monitor*



PHOTO 6: *8513 Color Monitor*

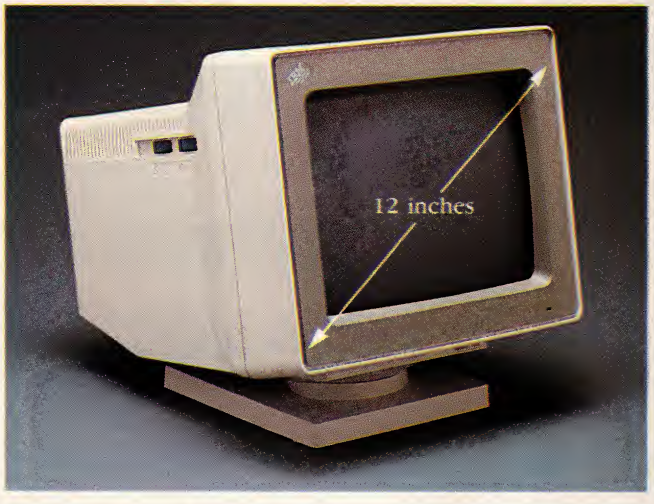
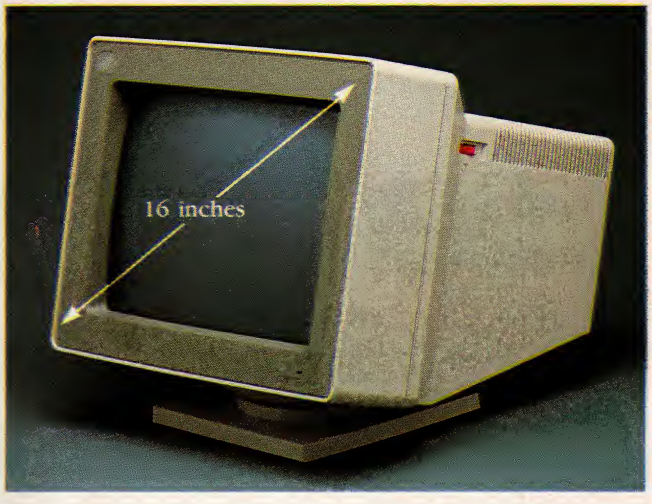
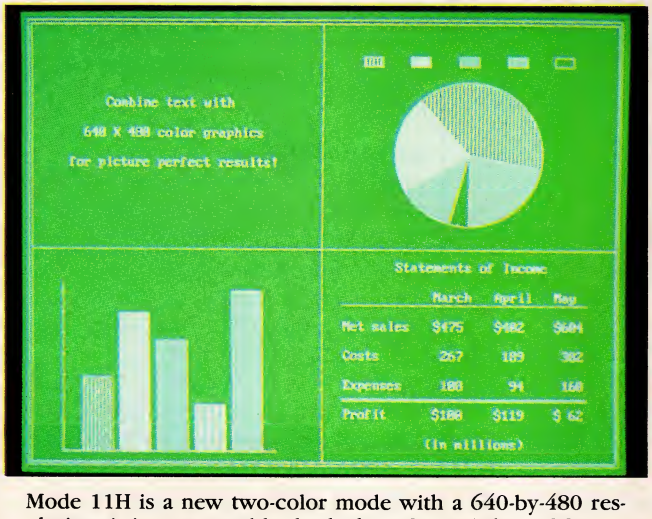


PHOTO 7: *8514 Color Monitor*



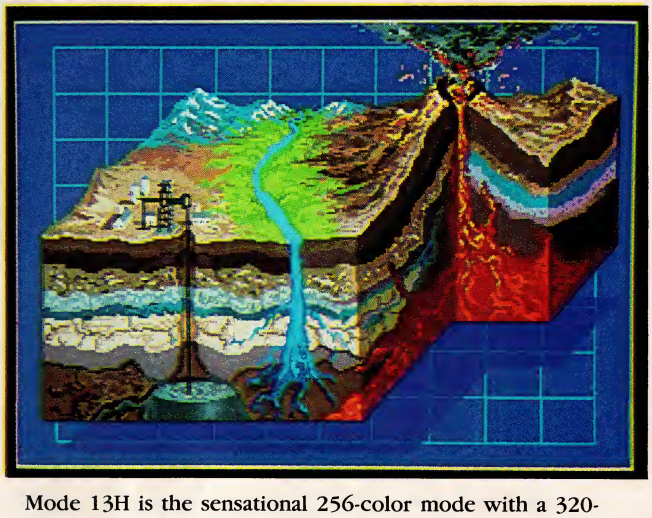
All of the new PS/2 analog monitors are interchangeable. Each offers a specific set of features. The 12-inch 8503 monochrome monitor displays up to 64 shades of gray; it is designed primarily for text applications. The 8512 is bigger and less expensive than the 8513 but does not have as clear a picture. The 16-inch 8514 is suitable for high-resolution workstation environments.

PHOTO 8: *Sample Screen in Mode 11H*



Mode 11H is a new two-color mode with a 640-by-480 resolution; it is supported by both the VGA and the MCGA.

PHOTO 9: *Sample Screen in Mode 13H*



Mode 13H is the sensational 256-color mode with a 320-by-200 resolution. Every video line is double-scanned.

TABLE 1: *Display Characteristics*

DISPLAY	SIZE	TEXT RESOLUTION	GRAPHICS RESOLUTION	COLOR SELECTION	PRICE
8503 Monochrome	12-inch	720-by-400	640-by-480	64 gray shades	$250
8512 Color	14-inch	720-by-400	640-by-480	256 colors from palette of 256,000	$595
8513 Color	12-inch	720-by-400	640-by-480	256 colors from palette of 256,000	$685
8514 Color	16-inch	1,024-by-768	1,024-by-768	256 colors from palette of 256,000	$1,550

The four PS/2 monitors provide a varied range. Monitors should be selected based on the type of application most often used.

TABLE 2: *BIOS Display Modes*

MODE	TYPE	ADDRESS	SCHEME	COLORS[a]	RESOLUTION	GLYPH CELL	COMMENTS
0	Text	B8000H	40-by-25	16	360-by-400	9-by-16	
1	Text	B8000H	40-by-25	16	360-by-400	9-by-16	
2	Text	B8000H	80-by-25	16	720-by-400	9-by-16	
3	Text	B8000H	80-by-25	16	720-by-400	9-by-16	
4	Graphics	B8000H	Split	4	320-by-200	8-by-8	Double scanned
5	Graphics	B8000H	Split	4	320-by-200	8-by-8	Double scanned
6	Graphics	B8000H	Split	2	640-by-200	8-by-8	Double scanned
7	Text	B0000H	80-by-25	Mono	720-by-400	9-by-16	
8, 9, A	IBM PC*jr* display modes (not supported by Personal System/2)						
B, C	Internal modes for font loading						
These modes encode color with parallel planar architecture as 8 pixels per byte:							
D	Graphics	A0000H	Linear	16	320-by-200	8-by-8	Double scanned
E	Graphics	A0000H	Linear	16	640-by-200	8-by-8	Double scanned
F	Graphics	A0000H	Linear	Mono	640-by-350	8-by-16	
10	Graphics	A0000H	Linear	16	640-by-350	8-by-16	
11	Graphics	A0000H	Linear	2	640-by-480	8-by-16	One-color, medium-resolution graphics
12	Graphics	A0000H	Linear	16	640-by-480	8-by-16	
This mode encodes 256 colors as 1 pixel per byte:							
13	Graphics	A0000H	Linear	256	320-by-200	8-by-8	Double scanned

[a] Maximum number of colors that can be displayed simultaneously from a palette of 256,000 colors, except in monochrome modes.

Besides the standard BIOS display modes, the VGA adds three color modes to increase its versatility: 11H, 12H, and 13H.

vertical resolution. However, the BIOS provides no assistance for drawing anything more complex than a single dot; all programs have to roll their own graphics routines.

TRUE COMPATIBILITY

True hardware compatibility with the previous display standard is not possible on the PS/2 machines; not only new monitors, but also new display adapters are necessary—the previous generation's display adapters do not fit into the chassis of machines using the new Micro Channel Architecture.

To determine software-interface compatibility, commercial applications using EGA features should be tested on the VGA—once the details for copying the program into a PS/2 have been established. In order to measure the degree of CGA and EGA compatibility, the VGA on a Model 50 was tested using a few application programs that could be transported into the Model 50: Microsoft Windows, Microsoft Word, RIX SoftWork's EGAPaint, and the SPRITES demonstration program presented in "Software Sprites," Michael Abrash and Dan Illowsky, August 1986, p. 125. Microsoft's Flight Simulator on 3.5-inch diskettes would not function on the Models 50 and 60 and produced unexpected colors on the Model 30, although it did function correctly.

Microsoft Windows 1.03, Microsoft Word 3.1 (on 3.5-inch diskettes), and EGAPaint all ran flawlessly. Windows ran in 640-by-350, 16-color mode—an important test because the EGA driver on Windows bypasses the BIOS for all screen operations except mode setting and also performs many different pixel operations. Word changed screen colors easily. The SPRITES program indicated not only a flawless degree of CGA compatibility, but also that the interrupt latch works correctly.

BIOS BYPASS

Applications that run correctly on the VGA probably use standard EGA features that are correctly replicated in the VGA and do not bypass the BIOS. However, many EGA applications bypass the BIOS in certain circumstances in order to increase performance.

The EGA BIOS contains minimal software pixel-handling assistance—it can draw only a single point—despite its much richer set of hardware pixel-handling functions. For example, the EGA can set 8 pixels at once, rapidly

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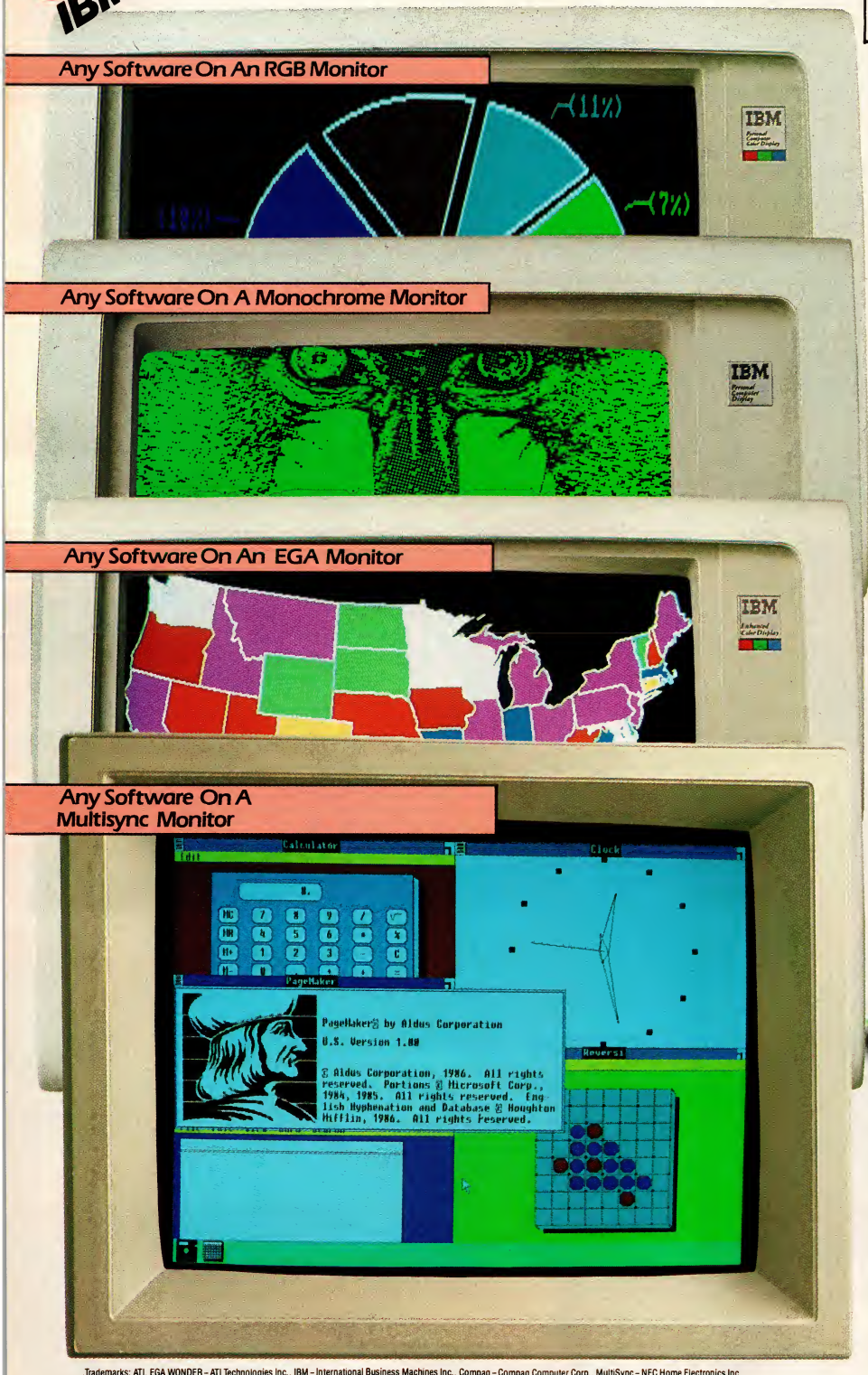
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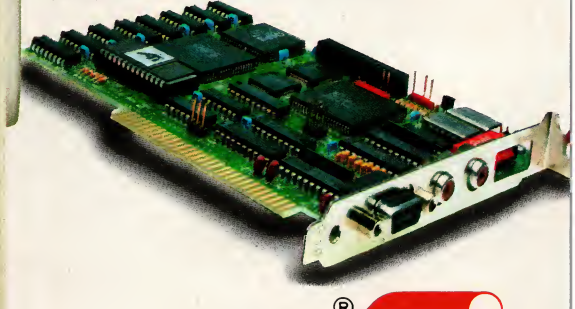
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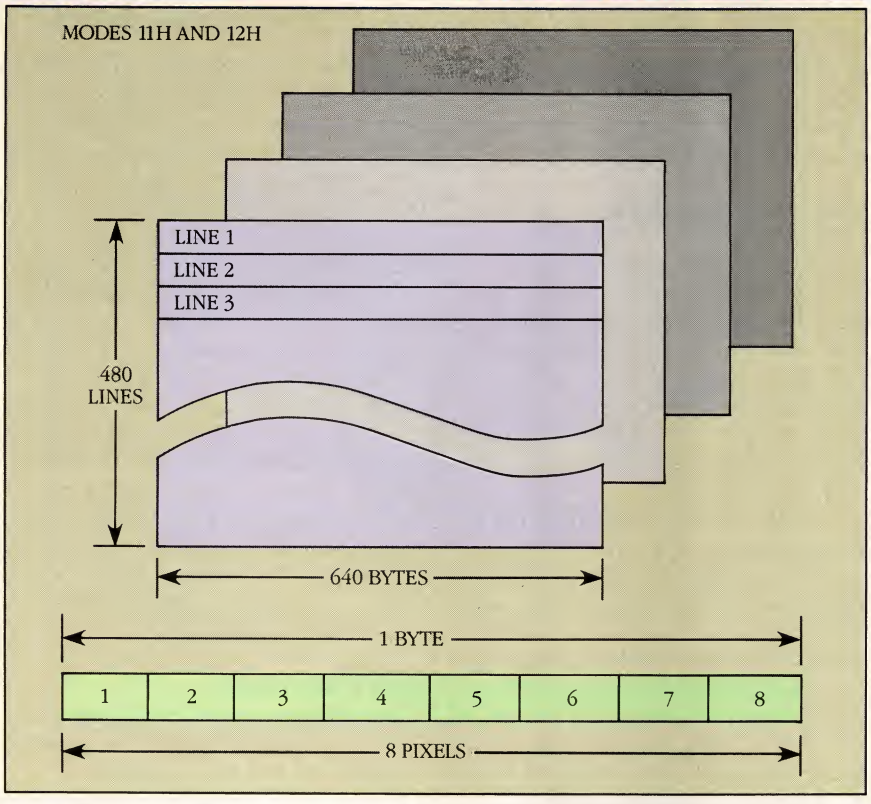
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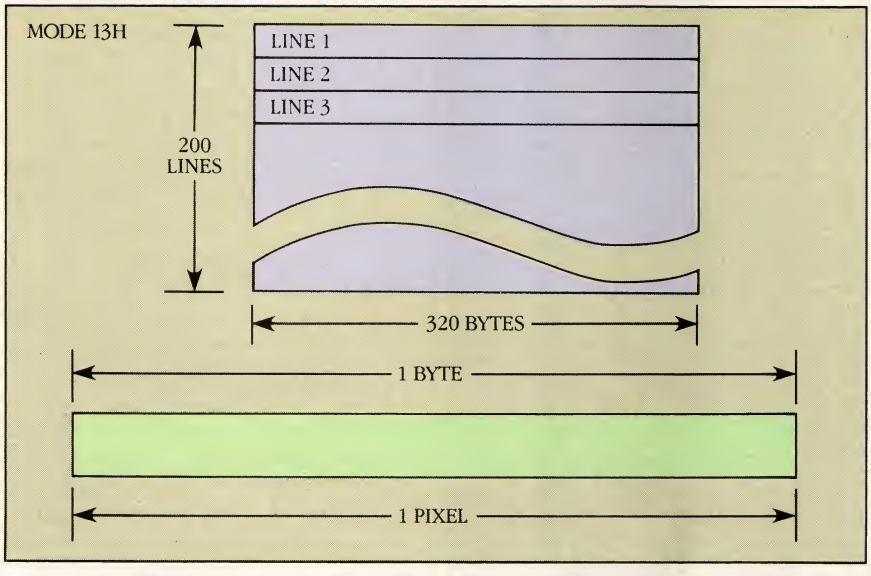
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FIGURE 1: *Display RAM Layout of Modes 11H and 12H*



In mode 11H, one plane is active encoding 2 colors; in 12H, all four planes are active encoding 16 colors. Display memory is organized as eight pixels per byte.

FIGURE 2: *Display RAM Layout of Mode 13H*



Mode 13H has a resolution of 320-by-200. Each byte codes one pixel, which, in turn, encodes 256 colors. Each video line in this mode is double-scanned.

move a byte-aligned block of pixels, and perform a complete set of logical operations on 8 pixels at a time. Many programs directly address the EGA hardware in order to use these pixel-handling functions. To be compatible with these programs, the VGA must replicate the EGA functions in hardware. Writing a BIOS to mask those differences is insufficient for porting applications to the VGA.

To overcome differences in the display hardware among the PS/2 models, the BIOS interface to the graphics subsystems and the mapping of display RAM are the same. However, because of differences between the VGA and the Model 30's MCGA, some BIOS functions do not work the same. In addition, the VGA, because of its complexity, has more functions.

The VGA is designed with many of the EGA's architectural features in order to preserve the EGA's display-buffer addressing modes and I/O interface. Display RAM is organized into four parallel bit planes, each of which is 64KB for a total of 256KB. Rudimentary pixel-handling assistance for these parallel bit planes is built into the graphics processor. The subfunctions share the same addresses with their counterparts on the EGA.

Despite outward appearances of complete compatibility, some EGA-specific applications that bypass the BIOS to set up their own nonstandard video state, must be modified to run on the VGA. IBM has expanded the functions of the EGA registers by using previously reserved bits, and the video parameters (horizontal and vertical counts and retrace signal timings) for the VGA CRTC are different from those parameters on the EGA.

Most EGA applications migrate easily to the VGA. Applications using the BIOS for all pixel operations continue to run perfectly; those that use the BIOS for mode setting, but use the GDC instead of the BIOS for pixel handling, also should work correctly. The remaining changes to the EGA functions in the VGA are either masked by the BIOS or so obscure that no current application takes advantage of them.

ONCE AND FUTURE COMPATIBILITY

Besides maintaining downward compatibility with the EGA, the VGA needs to be compatible across the PS/2 model line. IBM identified the need for model-independent software, which poses no problem for the three machines using the VGA—Models 50, 60, and 80. However, software that includes the Model 30 as well restricts the display modes and must take into account monochrome displays and the gray shading of color output.

Because new operating-system software will soon place additional requirements on the graphics subsystem, future compatibility also must be addressed. A multitasking, windowing system, for example, would create a need for display sharing among competing tasks—and a BIOS and hardware that support video-context switching. In addition, the VGA must be able to han-

dle the new requirements of the ever expanding functions of workstations, in particular increased performance and microprocessor speed.

As display resolution increases, display-buffer scan rates also must increase, and the microprocessor must compute and access more pixels in order to bring the image to the screen. The contention between these two competing processes creates a bottleneck. This bottleneck is not apparent in the EGA because of its lower resolution and slower microprocessors; when display RAM access contends for processing time, the CPU waits, because in the design of the EGA a clean screen image was thought to outweigh microprocessor throughput. With the increased resolution and microprocessor speed of the VGA, however, this bottleneck becomes more critical.

Because multiple fonts are needed for international word-processing and desktop publishing applications, both the EGA and the new PS/2 subsystems use soft fonts in which a programmer can change the pixel images of the characters. With soft fonts, a program also can change individual character sets on demand. In addressing these issues, IBM for the most part has preserved compatibility with the previous generation of graphics hardware.

HIGH-END GRAPHICS

Compatibility issues of the 8514/A high-end graphics adapter focus on how closely it resembles the PGC despite the fact that few applications operate directly on the PGC. Most applications rely on device drivers using ANSI-standard graphics programming systems such as the Graphical Kernel System (GKS) or the Computer Graphics Interface (CGI).

Unlike the PGC, the 8514/A has no microprocessor. The host CPU must provide the software interface to the adapter as a RAM-resident utility loaded at boot time. The 8514/A has a few integrated functions in silicon including bit-block transfers (bit-BLT) and rectangular clipping. These two functions improve the performance of the adapter over the PGC. Moreover, hardware clipping and bit-BLTs vastly improve the performance of Windows. The line-drawing and area-flooding functions are part of the software interface. Standards such as CGI and GKS can be built on top of this interface.

With the optional 512KB 8514 Memory Expansion Kit, the 8514/A provides up to 1,024-by-1,024 resolution with eight parallel planes providing 256 colors. Without the additional memory, the adapter has only four parallel bit planes and can produce only 16 colors.

The 8514/A does not come fully equipped. Instead, IBM offers certain 8514/A capabilities as a series of options, reminiscent of the EGA; for example, it cannot display all colors in the 1,024-by-768 high-resolution mode without the Memory Expansion Kit, which costs an extra $270.

VGA LIMITATIONS

In its efforts to preserve compatibility, IBM has advanced the standard by only a small step with its new baseline graphics. What is missing? Given the future role of IBM's Operating System/2 (OS/2) in all of the VGA machines, a number of hardware features could have been included in the VGA that would have benefitted both present and future operating environments.

Most importantly, the VGA should have included a 16-bit CPU bus interface for increased display RAM access performance. The VGA carries with it the baggage of its predecessor in that it is still an 8-bit device, even though it is built into a 16- or 32-bit machine. This fact alone accounts for many of the VGA's performance shortcomings. The 16- or 32-bit bus must emulate accesses to an 8-bit wide memory, which results in additional wait states.

The VGA does improve the CPU's drawing speed somewhat over that of the EGA, most notably in display RAM accesses. To help alleviate contention for the display RAM between the CPU and the VGA's 28-MHz dot clock, the VGA does not access display RAM during blanking intervals. In theory, this reduces the CPU penalty for display RAM accesses to an average of seven wait states during blanking—the penalty for accessing 8-bit RAM on the Model 50's 16-bit bus.

In addition, the VGA sequencer under program control can turn off CRT access to display RAM, momentarily blanking the screen. This gives the

ANALYZING PIXEL COUNTS

Why does the Video Graphics Array (VGA) provide only 320-by-200-pixel resolution with 256 colors? Why not 640-by-400? Although the VGA's 320-by-200 mode is impressive, IBM could have provided a 320-by-400 mode with 256 colors. The circuitry is in place for this higher-resolution mode because each vertical line is double-scanned, effectively yielding 400 lines on the screen. A 640-by-480, 16-color mode already exists: mode 12H.

However, the design of the VGA's architecture and its memory segmenting prohibit this higher resolution. In any mode requiring 256 colors, eight bits are needed to code for color; these eight bits can be organized into bytes, as in mode 13H, or into eight parallel bit planes. Because the VGA has only four bit planes, the color must be encoded into one byte for modes of 320-by-400 or 640-by-400. Encoding color into one byte means that a 320-by-400 mode requires 128KB, and a 640-by-400 mode needs 256KB to represent the full screen.

Although the VGA has 256KB of graphics RAM, its limit for a normal memory segment is 64KB; this limit is built into the chip set. However, a memory-mapping mode of two bit planes in two memory segments, A0000H and B0000H, raises this limit to a total of 128KB; each of these two bit planes can be interleaved in the VGA's *odd-even* mode (in which CPU addresses to the display buffer are modified so that the low bit toggles between two of the bit planes).

A 320-by-400 mode could have been created by using this memory mapping and by eliminating the double scanning present in the 320-by-200 pixel mode. Without altering the VGA CRT Controller (CRTC), the 256KB needed by a 640-by-400 mode in 256 colors cannot be mapped.

However, IBM has eliminated any possibility of the user creating a 320-by-400 mode by limiting the width of addresses generated by the CRTC in 320-by-200 mode to 14 bits—CRTC address bits 14 and 15 are tied off when the controller operates in 320-by-200 mode. Turning off double scanning in this mode causes the image to be replicated twice on the screen as the addresses wrap around.

By eliminating a 320-by-400 mode, IBM maintains compatibility across model lines. A 320-by-400 mode would have been difficult to provide on the Model 30's Multi-Color Graphics Array (MCGA). This is interesting because on the VGA, mode 11H (640-by-480, 2-color graphics) is only a subset of mode 12H (640-by-480, 16-color graphics). The only difference between the two is the setting of the internal palette.

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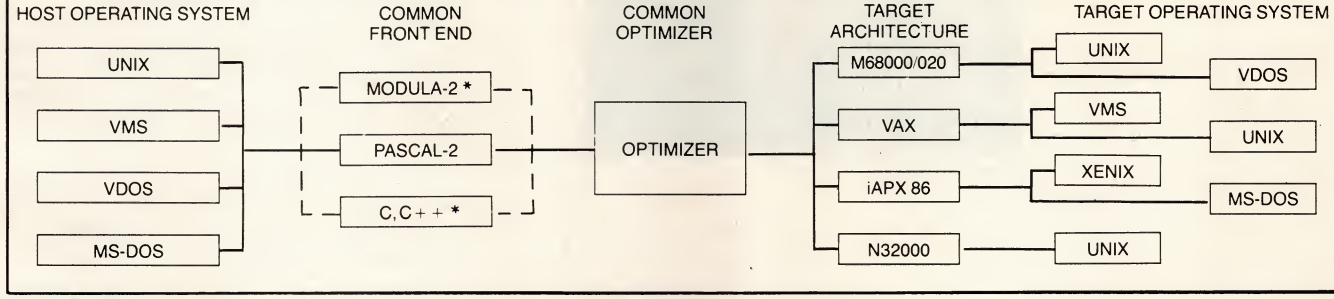
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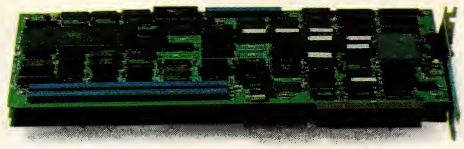
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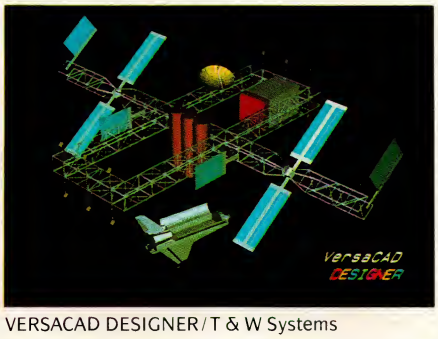
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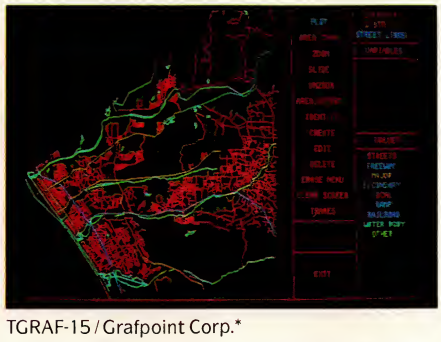


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CPU maximum display memory bandwidth. The sequencer also can tune the frequency of RAM refresh cycles to the display buffer in order to achieve even better performance.

The VGA easily could have provided hardware support for a graphics cursor or an icon, unloading this chore from IBM's windowing system, the Presentation Manager, which is based on Microsoft Windows. In heavily interactive applications, about 20 percent of the CPU's time is spent redrawing the cursor, most of which is consumed in special code saving and restoring the screen behind the cursor. OS/2 will use pop-up windows; hardware windowing also would be desirable.

The VGA does not support the light-pen interface in the CRTC. The reasons for this omission are unclear despite the anticipated migration to a graphics environment in which such a device is essential.

Because the four parallel bit planes have been successful for the architecture of the EGA, the logical next step for the VGA would have been eight parallel bit planes; in fact, some of the EGA-compatible chip sets currently can handle 8-bit planes. With 8-bit architecture, 256-color graphics would have been standard on the VGA for all graphics modes up to 640-by-480 pixels; instead, it is the exception. (See the accompanying sidebar, "Analyzing Pixel Counts," for more information.)

It is unclear whether the BIOS should have extended primitive drawing support beyond merely painting individual pixels. In a complex graphics environment, with the need for raster operations, clipping, and area filling, those primitive drawing functions would be abandoned quickly—about as quickly as the BIOS will be under OS/2. Perhaps in preparing the BIOS specification, IBM sought the functional lowest common denominator consistent with the entire PS/2 product line.

SERIOUS GRAPHICS

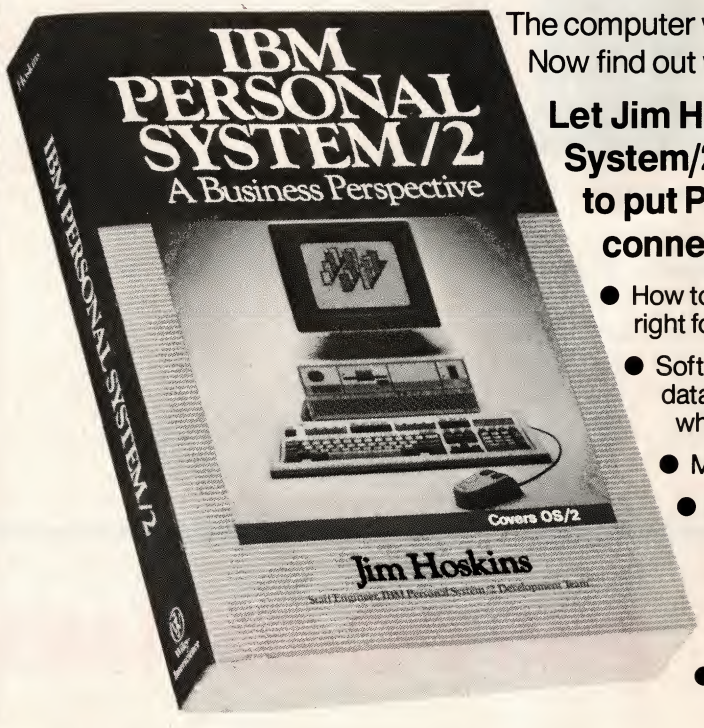
As the new graphics standard, the VGA is fine for most desktop applications—performance is acceptable and the price to performance ratio is reasonable. In a corporate environment, the built-in VGA reduces the number of different hardware configurations that must be supported. In addition, the PS/2 monitors are interchangeable.

As serious graphics hardware, however, the VGA has problems; developers soon will be demanding increased resolution in the 256-color mode. The VGA performance is adequate for most middle-level applications, but as more graphics-intensive applications become available, the bottleneck from display RAM contention will undoubtedly worsen, creating a serious problem for PS/2 graphics. These problems will persist until faster, more efficient components are incorporated. Given the rapid expansion of high-performance display hardware, the VGA does not advance far enough.

The near-term solution for jazzing up the graphics performance of the PS/2 family may be in migrating to the 8514/A adapter and 8514 monitor, although the $2,850 price tag of this combination may drive users to seek other solutions. Third-party manufacturers of display hardware will easily surpass the VGA and the 8514/A, and in another year or two the VGA could be relegated to the same unimpressive niche now occupied by the CGA. The evolution of the next graphics hardware generation will, if nothing else, certainly be colorful to watch.

John T. Cockerham, M.D., is a cardiologist at the Children's Hospital in Boston, where he is also a project manager for physician workstation development. His previous articles for PC Tech Journal *include reviews of the Enhanced Graphics Adapter in the October and November 1986 issues.*

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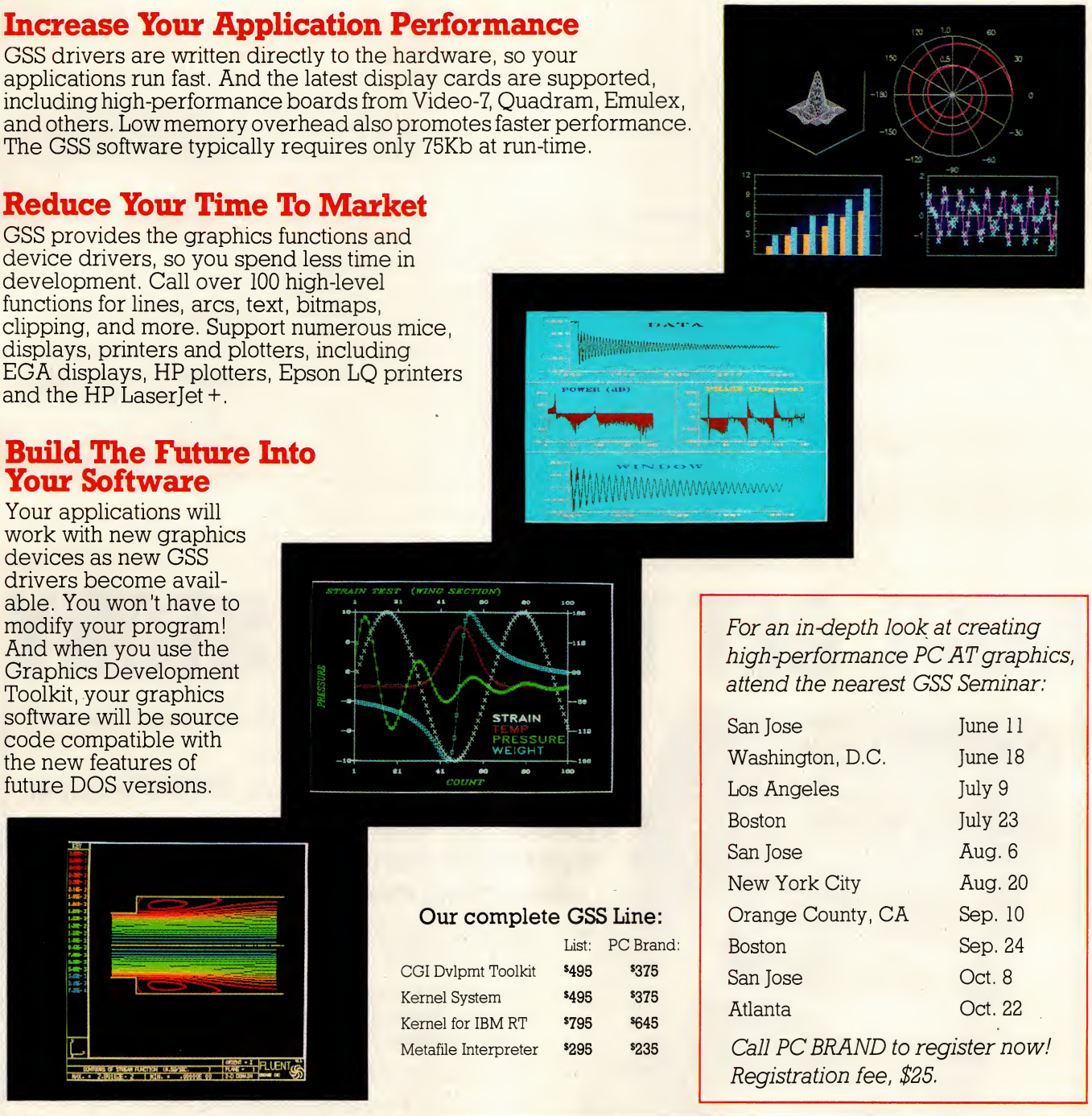
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GSS provides the graphics functions and device drivers, so you spend less time in development. Call over 100 high-level functions for lines, arcs, text, bitmaps, clipping, and more. Support numerous mice, displays, printers and plotters, including EGA displays, HP plotters, Epson LQ printers and the HP LaserJet +.

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Boston	July 23
San Jose	Aug. 6
New York City	Aug. 20
Orange County, CA	Sep. 10
Boston	Sep. 24
San Jose	Oct. 8
Atlanta	Oct. 22

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BRIEF NEW! *Version 2.0 Extends Lead*

Brief has come forth with version 2.0 offering editing templates for added languages, faster undo and search with matching over multiple lines, new types of block marking, large screen support, new documentation, and tutorials.

This runaway success has eclipsed all other editors by sporting every feature you've ever contemplated. Text, from keyboard or files, is housed in multiple buffers, and scrolled through one or more windows you open, close, resize. A text buffer may be called to different windows to view two areas at once. A change in one changes both. Text may be marked for printing, writing to files, movement to scrap buffers for cut and paste into other buffers or deletion, with as many backward "undos" as you want.

With a growing list of C compilers, you can compile without ever leaving Brief. It grabs the compiler's report of problem lines, and marches you through your source code for repairs.

Parts of Brief were written with its own Lisp-like macro language which has structure, 32-character variable names, conditional execution, loops, and even readability. Nothing like the hieroglyphs we've seen elsewhere. Bulletin board and public domain disks with macros. "One of the best investments you can make," *PC Magazine*. To top it off, there's a 30-day money-back trial period. List: **$195**, Us: **Call.**

CLIPPER *From Nantucket*

Compile dBASE for Speed, Protection

Clipper™ turns lumbering dBASE® into a speed dMON with benefits bobbing in its wake: your source code is submerged from public view, you can distribute your compiled application without royalties, and your customers don't even need copies of dBASE! The Spring '87 Clipper offers index files compatible with dBase III Plus, and networking capabilities to run compiled programs on major networks supporting DOS 3.1 with no restrictions on number of users. Clipper offers arrays, menu-building commands, user-defined functions, context-sensitive help techniques for applications, a debugger, and it supports Expanded Memory. It goes well beyond dBASE with 1,024 fields per data base and 2,048 active memory variables.

Clipper has the power to save and restore multiple screens to and from memory variables. You can also create overlays, call object modules compiled in other languages, and create function libraries to link with your applications. Power and flexibility make it the #1 dBASE compiler. List: **$695**, PC Brand: **Call.**

McMAX NEW! *From Nantucket*

Like dBASE for the Macintosh

McMax™ is like running dBASE on the Macintosh. It combines an easy-to-use menu-driven ASSIST mode using the Mac interface, an interactive command mode like dBASE at the dot prompt, and an application programming language fully compatible with dBase III. It gives you the power to create dBASE language applications on the Macintosh and transfer back and forth to the IBM® world. McMax accommodates up to 16 million records, 32,000 characters per record, 255 characters per field, and up to 32 files open concurrently. No copy protection. List: **$295**, PC Brand: **Call**.

30-DAY MONEY-BACK GUARANTEE

We refund the purchase price of any product returned within 30 days in entirely resalable condition. ***You can even try out programs themselves*** *if product code begins with E, T, or L through N — even if it means breaking the disk seal. Some developers do pose limits, so for products beginning with other letters, opening sealed disks constitutes acceptance. But you can at least review the manual. There's just nothing stopping your buying from PC Brand.*

MICROSOFT C 4.0

A Great C Battle Rages and You're Winning

It bundles a source debugger and a "make", and sports a "huge" memory model permitting single data objects larger than 64k, but what's really impressive about Microsoft C are the benchmarks reported in Dr. Dobb's. Microsoft runs away from a field of 17 winning 11 of 27 benchmarks.

The CodeView™ debugger uses windows to show everything on one screen: source alongside disassembled object, variables, stack and registers. Drop down windows obviate learning of commands. "A source-level debugger that puts the rest to shame" said Dobb's.

Microsoft C has five memory models for code and data, plus non-library support for another thirteen, and boasts alternate math packages for speed versus accuracy, with or without 8087/80287 chips.

Both linker and library manager are part of the package, as is the "make", which knows how to rebuild any size project by compiling only elements which have changed.

It is reportedly used by Lotus, Ashton-Tate and, fittingly, Microsoft itself to develop Windows. Dobb's calls it "the best MS-DOS C development environment value today [for] virtually any kind of program conceivable." 320k suggested.

Ask for:	List:	PC Brand:
G0500	**$450**	**$295**

HALO GRAPHICS SYSTEM *Multi-Board Graphics Library*

The premier graphics library that got the ball rolling for PC-based graphics and has grown so omnipotent that it supports over 25 graphics boards — including IBM's EGA and Nr. 9 Revolution's hi-res series — and has a multitude of mouse and printer drivers. All that in each box. Separate C versions for Lattice, M'soft, Aztec, CI86. What does Multi-Halo do? A down to the last pixel graphics library plus functions to reset drivers so distributed program can run on anything. Wonderful value for single license. Costly royalties though for redistribution. Specify: S0315 & Language. List: **$300.** We: **$219.** With Dr. Halo II, a free-standing "paint": List: **$440,** Us: **$299.**

C-TREE & R-TREE *B-Tree File Manager Now Has Report Generator*

c-tree: Seasoned to perfection, c-tree™ is the only major b-tree file manager with network support in the standard low-cost version. It allows multiple users to access an index file simultaneously even during updating. Record-locking routines are provided for DOS 3.x, UNIX and XENIX.

C-tree even comes in C source code, yet there are no royalties. Source sticks to K&R, so C-tree is portable. Tests in many environments prove it.

C-tree permits any number of keys for a data file—alpha, numeric, even floating point. It handles files with varied record lengths and keeps multiple keys in one index file. Has both high level ISAM routines to handle details with minimum coding, and decomposed step-by-step functions you can access directly. In short, you get the works.

r-tree: thousands of c-tree users (and you) now have a suddenly expanded ability to produce ad hoc reports from files maintained by c-tree (v. 4.1 and up). Just link a file description to the r-tree library, and all you need is an ordinary text editor to write any number of report scripts with no further C coding. Reports can access data in several files, select on criteria, join the findings into new logical records, sort them, calculate new fields and columns, tabulate by any number of control breaks. The script files show a visual representation of the report image for easy creation and maintenance of even elaborate layouts. r-tree™ comes in source, boasts the same portability as c-tree, and fits any compiler.

	List:	PC Brand:
c-tree: F0660	**$395**	**$329**
r-tree: F0665	**$295**	**$245**
Combined:	**$650**	**$541**

dBC *Lattice Library Maintains dBASE Compatible Files With the Power and Speed of C*

dBC™ links C to dBASE. It creates and maintains files and their indexes which exactly replicate dBASE file design. So dBASE can read and update them. And the reverse. dBC can use any files created by dBASE. Now C and dBASE can operate on the same data bases interchangeably.

That opens up the widespread culture of dBASE installations to exploitation by C programmers. Tap that market, avoid the resident dBASE language, and gain the advantages of C with this single product.

dBC's functions parallel all dBASE's file handling commands, many decomposed to give closer control. Each backed by demo source files on disk.

Use dBC for custom work for clients, or on its own. It's a complete ISAM file manager for C whether or not dBASE will be used in tandem, supports all four memory models, and can have sixteen index and data files open. Big discount to buyers of both dBASE II and III versions. Specify Lattice, Microsoft 3.x, or DeSmet.

Versions:		List:	PC Brand:
L00II	For dBASE II	**$250**	**$195**
LCCII	With Source	**$500**	**$390**
L0III	For dBASE III	**$250**	**$195**
LCIII	With Source	**$500**	**$390**

POLYTRON VERSION CONTROL

Source Code Control for Any Language

PVCS allows programmers, project managers, librarians and system administrators to control the proliferation of revisions and versions of source code in software systems. Independent programmers, the leading software publishers and LAN companies, and hundreds of Fortune 1000 companies rely on PVCS to store and retrieve multiple revisions of text. It maintains a complete history of revisions as an "audit trail", generates status reports, and uses intelligent "difference detection" to minimize disk space for each new version.

On Corporate and Network PVCS simultaneous changes to a module are merged into a single new version. If changes conflict, the user is notified. The "Logfiles" used to track changes are interchangeable between any PVCS product.

Corporate PVCS is for multiple programmers. It includes "branching" to maintain code when programs evolve on multiple paths. Personal PVCS offers most of the power and flexibility of corporate PVCS, but excludes multiple programmer features. Network PVCS is the Corporate version for LANs. File locking and security levels can be tailored to each project.

PolyMake Still using a prehistoric Make? Step up to PolyMake, the most popular and powerful Make utility. Most flexible macros of any Make. Now integrated with PVCS and PolyLibrarian for faster performance and precise configuration management.

Ask for:	List	PC Brand:
Personal PVCS	**$149**	**$109**
Corporate PVCS	**$395**	**$309**
Network PVCS	**Call**	**Call**
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SUPER SOURCE

Two great debugging and documentation tools that support C, Modula, Pascal, BASIC, and dBASE:

Source Print

Author Alan Simpson writes "the best overall debugging technique is to... draw lines to connect all the IFs and DO WHILEs etc. with their ENDIFs and ENDDOs. Use a pen or pencil to..." Well thanks, Alan, but we'll let Source Print do it for us. It draws vertical lines to connect all such beginnings and endings in a vivid display of your program's organization. And it can print programs with page numbers, headings, line numbers, indent automatically, throw in a table of contents and a cross-reference index. About Source Print *PC Magazine* said, "Occasionally a utility comes along that makes a programmer's life much easier." List: **$75**, Ours: **$60**.

PANEL PLUS *Library Source Code Gives It Complete Portability*

NEW! NO ROYALTIES!

There are no end of tools for screen design and data entry, but none quite like Panel Plus. Design a screen under program control, use Panel's utility to "run" and test it field by field, then pass it to Panel's code generator which delivers C source code. Options style the code to your compiler's liking, and you can of course do what you like to the source afterward. The code calls Panel Plus's function library, but now *the library comes in source,* so everything produced is highly portable. Not like other screen managers delivered as object libraries and which leave *you* to write the detailed code.

Panel Plus will operate in graphics mode via interfaces to graphics products it supports and can utilize the EGA's 43-line screen. Low-level I/O functions adapt it to various keyboards, screens, operating systems.

Panel's newest incarnation has every imaginable feature. A single screen design can have 1000 fields stacked as visual overlays up to 127 levels deep or as pop-ups. Groups of fields can be moved between levels. Screens can be output as compilable code or stored on disk for loading at run-time. Each field can be boxed, colored, multi-row, word-wrapped, and scrolled horizontally and vertically if larger than its on-screen view aperture. It can be assigned its own help and error message, can be told to accept certain characters, or to match a picture, and to check data after entry—proper dates, number ranges, etc.—using Panel's or your own validation routines. You can add your routines to Panel's test utility because even it comes as source. Fields are accessed in any order and control reverts to your application program after each field for choice of action.

For past Panelists, the new version has smaller and faster field and screen functions, tighter granularity, and an enhanced, reworked library. Major tool for the serious developer. List: **$495**, PC Brand: **$395**.

..and Tree Diagrammer

Tree Diagrammer prints an organization chart of your program's structure showing the hierarchy of function, procedure, and subroutine calls. Shows at a glance what routines call each other for clearer debugging. Every shop should have this important documentation tool. List: **$55**, Ours: **$45**.

Shopping List for the Power Workbench

	LIST	US
ARITY PRODUCTS		
Arity Combination Package	1095	979
Expert System Development Pkg	295	229
File Interchange Toolkit	50	44
PROLOG Compiler & Interpreter	650	569
Screen Design Toolkit	50	44
SQL Development Package	295	229
Arity PROLOG Interpreter	295	229
Arity Standard Prolog	95	77
AI-EXPERT SYSTEMS		
Autointelligence *by IntelligenceWare*	990	739
Experteach II *by IntelligenceWare*	475	339
EXSYS *Development Software by EXSYS*	395	309
EXSYS Runtime System	600	469
Insight 2+ *by Level Five Research*	485	379
Intelligence/Compiler *IntelligenceWare*	990	739
AI-LISP LANGUAGE		
IQCLISP *by Integral Quality*	300	Call
IQLISP *by Integral Quality*	270	Call
Microsoft LISP *Common LISP*	250	189
TransLISP *from Solution Systems*	95	Call
TransLISP PLUS *from Solution Systems*	195	Call
AI-PROLOG LANGUAGE		
APT *Active Prolog Tutor from Solution Sys.*	65	Call
MPROLOG Language Primer *LOGICWARE*	50	45
MPROLOG P500 *by LOGICWARE*	495	395
MPROLOG P550 *by LOGICWARE*	220	175
Prolog-86 *from Solution Systems*	125	Call
Prolog-86 Plus *from Solution Systems*	250	Call
Turbo PROLOG *by Borland Int'l*	100	63
Turbo PROLOG Toolbox *by Borland Int'l*	100	64
ASSEMBLERS & DEBUGGERS		
Advanced Trace-86 *Morgan Debugger*	175	119
C-Sprite Debugger *by Lattice, source level*	175	139
Microsoft Macro Assembler *with Utilities*	150	109
PASM86 *by Phoenix, Macro Assembler*	195	125
Periscope I Debugger...*The Periscope Co.*	345	289
Periscope II *with NMI Breakout Switch*	175	139
Periscope II-X *software only*	145	105
Periscope III *with Advanced Board...New*	995	Call
BASIC LANGUAGE		
Microsoft BASIC Interpreter *for XENIX*	350	295
Microsoft QuickBASIC Compiler...*3.0*	99	79
BORLAND PRODUCTS		
Reflex & Reflex Workshop	200	129
Reflex *Data Base System*	150	89
Reflex Workshop	70	45
Turbo Basic...*New*	100	64
Turbo C Compiler...*New*	100	64
Turbo Lightning	100	64
Turbo Pascal & Tutor...*New*	125	85
Turbo Pascal with 8087 & BCD	100	64
Turbo PROLOG Compiler	100	63
Turbo PROLOG Toolbox	100	64
Turbo Tutor	40	28
C COMPILERS		
C86 PLUS *by Computer Innovations...New*	497	397
Lattice C Compiler *from Lattice*	500	299
Let's C Compiler *by Mark Williams*	75	55
with CSD Source Level Debugger	125	90
MWC-86: Mark Williams C Development	495	369
Microsoft C Compiler...*4.0*	450	295
Turbo C Compiler *by Borland...New*	100	64
C INTERPRETERS		
C-Terp *by Gimpel Software*	300	249
Instant C *by Rational Systems*	500	395
Interactive-C *by IMPACC with debugging*	249	219
RUN/C Professional *from Lifeboat*	250	185
COMMUNICATIONS		
Asynch Manager *by Blaise, for C or Pascal*	175	117
Greenleaf Communications *by Greenleaf*	185	139
C UTILITY LIBRARIES		
Blaise C Tools Plus	175	117
Blaise C Tools	125	84
Blaise C Tools 2	100	67
C Food Smorgasbord *by Lattice*	150	109
C Utility Library *by Essential, 300 functions*	185	139
Greenleaf Functions *by Greenleaf Software*	185	139
COBOL LANGUAGE		
RM/COBOL...*see Ryan-McFarland Prod.*		
Microsoft COBOL Compiler	700	499
Microsoft COBOL Compiler *for XENIX*	995	795
Micro Focus COBOL...*see Micro Focus Prod.*		
dBASE SUPPORT		
BRIEF/dBRIEF...*Brief for DBASE III*	275	Call
CLIPPER...*from Nantucket*	695	Call
McMAX...*dBASE for MAC from Nantucket*	295	Call
dBx..*dBASE to C Translator by DESKTOP AI*	350	299
with Library Source Code	550	469
with Full Source Code	1000	855
dBC...*from Lattice...maintains DBASE files*	250	195
with source	500	390
dBC III Plus...*supports multi-user DBASE*	750	595
with source	1500	1185
DEVELOPMENT TOOLS		
BASTOC *by JMI, convert BASIC to C*	495	399
BASIC-C *BASIC's functions added to C*	175	139
Report Option *Softcraft Btrieve Report Gen.*	145	128
Xtrieve *Softcraft Query Utility for Btrieve*	245	220
Code Sifter *Profiler by David Smith*	119	89
Dan Bricklin's Demo Program *Prototyper*	75	69
LMK *from Lattice, "make" like UNIX*	195	149
Microsoft Window Development Toolkit	500	365
ESSENTIAL PRODUCTS		
C Utility Library	185	119
Essential Graphics	250	183
Essential Comm Library	185	125
with Breakout Debugger	250	189
FILE MANAGERS		
Btrieve *by Softcraft, no royalties*	250	195
Btrieve Network *by Softcraft*	595	465
C-Tree *by FairCom - no royalties, source*	395	329
R-Tree *by FairCom-Report Generator*	295	245
C-Tree & R-Tree Combo *by FairCom*	650	541
dbVista *single user DBMS by Raima*	195	139
dbVista *multi-user DBMS*	495	399
Opt-Tech Sort *Can sort Btrieve files*	149	105
FORTRAN LANGUAGE		
RM/FORTRAN *by Ryan McFarland*	595	499
FORTRAN Libraries...*by Alpha Computer*	70	45
Microsoft FORTRAN *Links w/Microsoft C*	450	281
Microsoft FORTRAN *for XENIX*	695	546
Scientific Subroutine Package *by Alpha*	295	239
GRAPHICS		
Essential Graphics *Essential, no royalties*	250	210
GSS Graphics Development Toolkit	495	375
GSS Kernel System *by Graphic Software*	495	375
GSS Metafile Interpreter	295	235
Halo *by Media Cybernetics*	300	219
with **Dr. Halo II**	440	299
Halo for Microsoft *includes all fonts*	595	434
MICRO FOCUS PRODUCTS		
Micro Focus Level II COBOL *w/Animator*	495	395
Level II COBOL	349	279
Level II Animator	195	155
Micro Focus Personal COBOL	149	99
Forms-2	295	235
MODULA-2 LANGUAGE		
MODULA-2 Apprentice Pkg *by LOGITECH*	99	79
MODULA-2 Magic Pkg *by LOGITECH*	99	79
MODULA-2 ROM Pkg & Cross RT Debugger	299	239
MODULA-2 Window Pkg *by LOGITECH*	49	39
MODULA-2 Wizard's Pkg *by LOGITECH*	199	159
OTHER LANGUAGES & UTILITIES		
Source Print...*source code formatter*	75	60
Tree Diagrammer..*source code diagrammer*	55	45
Help/Control *by MDS...123 style Help*	125	109
Microsoft MuMath *includes MuSimp*	300	199
Microsoft Pascal Compiler *Links w/M'soft C.*	300	199
Microsoft Pascal Compiler *for XENIX*	695	546
Turbo Power Tools+ *by Blaise*	100	67
Advantage C++ *by Lifeboat Assoc.*	495	435
PHOENIX PRODUCTS		
PASM86 *Macro Assembler*	195	125
PDisk *Phoenix's new disk manager*	195	125
Pfantasy Pac *six products...New Price*	995	Call
PFinish *EXE performance analyzer*	395	235
Pfix86 Plus *Symbolic Debugger*	395	235
PforCe *vast library*	395	235
PforCe++...*Function Library for C++*	395	235
Plink86 Plus *Utilizes memory for overlays*	495	325
Pmaker *like UNIX "make"*	125	85
Pmate *with Macros*	195	115
Pre-C *UNIX "lint"-alike*	295	174
PTel *Binary File Communicator*	195	115
POLYTRON PRODUCTS		
PVCS Corporate...*Source Code Control Syst.*	395	309
PVCS Personal	149	109
PVCS Network	Call	Call
PolyMake *Complete Make Utility*	149	109
PolyLibrarian *Library Manager*	99	73
PolyLibrarian II *Library Manaer*	149	109
PolyShell *UNIX-like Command Shell*	149	109
PolyXREF *Complete Cross Ref Utility*	219	169
PolyXREF *One language only*	129	99
PolyBoost *The Software Accelerator*	80	64
PolyDesk III *3rd Generation Desktop Org*	99	73
PolyDesk III *Add On Tools*	Call	Call
RYAN-McFARLAND PRODUCTS		
RM/FORTRAN...*2.4 New*	595	499
RM/FORTRAN...*UNIX or XENIX*	750	599
RM/COBOL...*DOS*	950	799
RM/COBOL...*UNIX or XENIX*	1250	999
RM/COBOL Run Time	250	199
RM/COBOL 85...*ANSI 85 COBOL*	1250	995
RM/COBOL 85 RUN TIME	300	249
RM/SCREEN...*for COBOL 85*	395	335
RM/NET +5...*COBOL & COBOL 85 Network*	300	249
SCREEN DESIGN		
Curses *by Lattice, UNIX screen designer*	125	99
with Source	250	199
Greenleaf Data Windows...*New*	225	169
with source	395	297
Panel Plus *by Round Hill, no royalties..New*	495	395
View Manager for C *by Blaise*	275	164
Vitamin C *by Creative Programming*	225	198
VC Screen *by Creative Programming*	100	81
Windows for C *Vermont Creative Software*	245	216
Windows for Data *includes Windows for C*	395	349
ZView *Data Management Consultants*	245	175
TEXT EDITORS		
Brief *from Solution Systems*	195	Call
Condor Editor *by Condor*	130	118
Edix *by Emerging Tech...Multi-screen*	195	159
Epsilon *by Lugaru Software, like EMACS*	195	149
FIrsTime *by Spruce Technology, C syntax*	295	229
Kedit *by Mansfield, similar to Xedit*	125	99
LSE, the Lattice Screen Editor *Multi Wind.*	125	100
Vedit *by Compuview*	150	99
Vedit Plus *by Compuview*	185	129

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dBx: dBASE AT THE SPEED OF C

Translates dBASE Applications to C

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The answer is dBx. It translates dBASE to C. It offers you a major competitive advantage over the next dBASE programmer. But not by converting everything you've ever written to C including you. Rather, keep right on writing in dBASE. Take every application all the way to completion. Then use dBx to translate it top to bottom to C source code and compile it.

There are other advantages. C is portable, even to other operating systems like UNIX™/XENIX™ as well as to the Macintosh or Amiga. dBx is the gateway for your applications to places where dBASE cannot go. (Library source needed for non MS-DOS).

dBx has its own file management utility for single user, but links to major C file managers—c-tree™ and dBC—for both compatibility with dBASE files and multi-user support. And you'll need a C compiler. We have everything to get you under way, including good advice. So call us when you're ready to put to C.

	List:	PC Brand:
dBx	$ 350	$299
with Library Source	$ 550	$469
with Full Source Code	$1000	$855

Call for special dBx Translation System pricing with includes dBx, C compiler, and File Manager.

ESSENTIAL C UTILITY LIBRARY

400 Functions, 30¢ Each

You've probably seen the speed and power of Essential's C function library without knowing it. Software greats have been using it for some time to give today's top products pizazz and panache.

Now grown to 400 functions Essential's collection features routines to produce pop-up menus, save and restore screens and windows to disk or memory in as little as 1/10th second, and the fastest video output available. Screen handling covers scrolling, paging, word processor functions to insert, delete and clear to end of lines or screen. Library has a complete set of 50 business graphics functions, 40 string handlers, 28 functions for printers, 18 for mice, 11 for time and date. Its DOS interfacing functions offer disk error trapping to keep DOS from intruding on your program, and directory and file management with file creation, file search using wild cards, plus acquisition and change of file attributes. Everything comes in source, including sample programs that demo library functions. We have versions with prebuilt libraries for all well-known C compilers, and a source code librarian is supplied for rolling your own.

	List:	PC Brand:
C Utility Library	$185	$119
Essential Graphics	$250	$183
Essential Communications	$185	$125
with Breakout Debugger	$250	$189

ZVIEW

Screen Design Aid

A complete package for screen design with full windows management as a bonus! Easy creation of screens with complex validation, such as range checking or required/optional data. Powerful Screen Paint utility for creating or editing applications screens. Built in security levels, set at run-time, control read or read/write access by field or screen. Automatic help screen processing for run-time aid per field or screen. Applications regain control during field tabbing, allowing run-time on-screen transaction processing or flow control. Run-time functions include Screen Read and Write with automatic transparent data conversion from screen image to data storage, Field Editing, Help Screen Processing, even a capability to change any field characteristic at run-time, plus Window Push Pop and Scroll. Versions for Lattice, Microsoft and Aztec C. Automatic free updates to registered users. No run-time royalties. List: $245 PC Brand: $175

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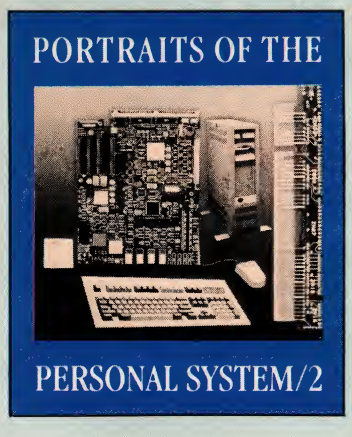
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4TJ8/87



Model 30: Apart from the Family

TED MIRECKI

Lacking some of the PS/2 family traits, the Model 30 has to find its identity before taking its rightful place in the market.

The entry-level Personal System/2 Model 30, by virtue of its 8086 microprocessor and standard PC bus, is no more than a souped-up PC/XT-class computer. While an interesting machine in its own right, the Model 30 leaves the issue of its family background entirely open to question: does it really belong in the PS/2 family?

Strictly speaking, the definition of PS/2 is whatever IBM wants to make it, and if IBM attaches a PS/2 nameplate to the Model 30, then so be it. Yet this machine obviously is very different from Models 50, 60, and 80—at best, it is a distant cousin. The temptation is ever present to qualify why it does or does not belong in the family and to define exactly what, besides marketing tactics, determines the PS/2 pedigree.

The Model 30 lacks many of the characteristics that define the rest of the PS/2 models. For example, it does not incorporate the new graphics standard of the PS/2 family, the Video Graphics Array (VGA).

A more fundamental difference is that the Model 30's 8086 microprocessor means that it will not be able to run IBM's new Operating System/2 (OS/2). Although the ability to run a protected-mode operating system is in itself not sufficient qualification for PS/2 membership (the PC/AT and XT 286 will run it, yet they are not members), it is a major dividing line between the past and the future of desktop computing. In that regard, the Model 30 cannot move beyond the present.

The most compelling reason for the Model 30's questionable status is its lack of the single most significant innovation in the other PS/2 models: the Micro Channel Architecture. That is what really sets apart the Models 50, 60, and 80 from the PC, XT, AT, and, yes, the Model 30.

Even apart from the absence of the Micro Channel, the construction of the Model 30 is unlike that of the other PS/2 models. In most respects, it resembles a scaled-down XT: the chassis is metal, the cooling fan is inside the power supply, and the disk-drive and power-supply connections are cabled. The density of components inside the system unit is lower than in the Model 50 (see photo 1); for example, the space above the system board between the power supply and the bus adapter is unused. The only construction characteristic shared with the Model 50 is the disk-mounting bracket, but otherwise the Model 30 has very little in

common with the innovative design of the rest of the PS/2 family.

The Model 30 must be matched with the 8088-based PC and XT for a fair comparison. It is hardly impressive when judged against the AT or its closest PS/2 relative, the Model 50, both of which use 80286s. The Model 30 has an Intel 8086 running at 8 MHz, which is basically the same as the 8088 in the PC and XT, except that it can read and write memory 16 bits at a time. Standard memory is 640KB.

Two different configurations are available: the 30-002 has two 3.5-inch inch diskette drives, each with a capacity of 720KB; the 30-021 has one diskette drive and a 20MB hard disk with a slow 80-millisecond average access time. The high-capacity 1.44MB diskette drives that are standard on the other PS/2 models are not available for the Model 30. A parallel port, serial port, mouse port, video controller, realtime clock/calendar, and diskette-drive controller are incorporated on the system board (see photo 2).

The majority of the chips on the system board are surface-mounted. Only five of them are socketed: the 8086 processor, the 8087 math coprocessor, two ROM chips, and a chip in the video circuitry. A number of through-mounted DIP chips are also present.

Three expansion slots take standard full-length, 8-bit XT-style adapter cards. Even with the complement of features incorporated on the system board, three slots seem barely adequate. The Model 30 user who wants to add graphics enhancements, memory based on the Lotus/Intel/Microsoft Expanded Memory Specification (EMS), and networking or other communications boards may run out of expansion space. In comparison, an XT equipped with a graphics adapter, diskette and hard-disk controllers, and a multifunction board with memory, I/O ports, and a clock, leaves four slots open—or more if higher-density expansion boards are used (for example, boards combining both disk controllers, or those combining memory, I/O ports, and graphics in one slot).

The Model 30's graphics controller, called the Multi-Color Graphics Array (MCGA), provides only a subset of the capabilities of the VGA that is standard in the rest of the PS/2 line. At the BIOS level, the MCGA emulates standard CGA, but not EGA, graphics. The Model 30 does use the same analog monitors as the other PS/2 models, and VGA capabilities can be added with the PS/2 Display Adapter, a plug-in expansion board. (For additional information on the MCGA, see the sidebar "Model 30 Graphics," John T. Cockerham, this issue, p. 95.)

The Model 30 provides no outlet for a monitor, so the system cannot be turned on with one switch except from an external outlet box. The power supply, rated at 70 watts of output, adjusts automatically to input voltages of either 110 or 240 volts and line frequencies of either 50 or 60 Hz.

Operating the system requires DOS 3.3, which must be purchased at extra cost. Besides the Cassette BASIC built into the ROM, the only software supplied with the system is the demonstration program "Exploring Your System" and the standard diagnostics. As in all previous PC models, Cassette BASIC provides the core of Advanced BASIC, but it has no practical use outside of DOS. Because there is no cassette port present, both the name and possibility of activating this software are mere anachronisms.

EXTERNAL FEATURES

The system unit measures 16 inches wide, 15.6 inches deep, and 4 inches high. Its footprint is 20-percent smaller than that of the XT. Compared with the Model 50, its footprint and volume are not significantly different, but the Model 30 appears larger from the operator's viewpoint because it is wider.

Each of the two disk-drive bays can hold one 3.5-inch drive or a hard disk of the equivalent size. The Model 30, therefore, cannot accommodate two diskette drives and a hard disk. Nor does it contain sufficient room for an internal 5.25-inch diskette drive; an external unit is available, however.

The disk drives slide into rails on a plastic mounting platform attached to the front right of the system unit. The mechanical mounting is the same as in the Model 50, but the electronic connection is quite different. In the Model 30, the drives are connected to the system board with ribbon cables.

The front panel carries the access lights for the two disk drives as well as the power switch. Unlike the AT and the other PS/2 models, however, the Model 30 has no pilot light to indicate if the system unit is turned on. As on all other IBM models past and present, no reset switch is provided.

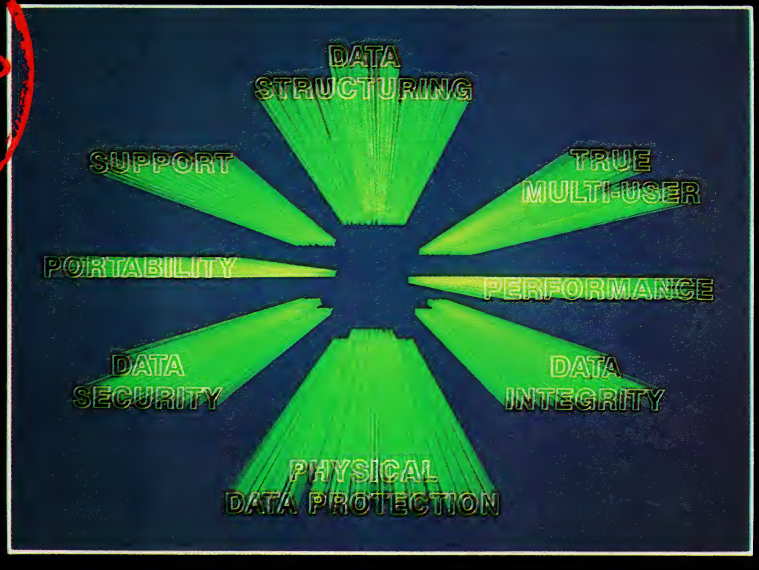
The keyboard is the same 101-key enhanced



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model that IBM has proclaimed the standard across its entire line of personal computers and terminals. Although the system's interface with the keyboard is unique to this model, the keyboard itself is interchangeable with the other PS/2 models and current versions of the XT and AT. The connector at the system unit end of the keyboard cable is new (it is a miniature 6-pin DIN plug), but the connector at the other end of the cable is the same as on the keyboard supplied with the AT.

In addition to the DIN connector for the keyboard, the rear panel has connectors for the IBM mouse, monitor, parallel port, and serial port (see photo 3). The mouse connector is identical to the keyboard connector. The monitor uses a connector with 15 pins in three rows instead of the 9-pin DB connector used by previous monitors. The serial port connector is the same 25-pin DB connector as on the XT, not the 9-pin used on the AT.

PS/2 MODEL 30 VITAL STATISTICS

Model 30-002: $1,695
8-MHz Intel 8086 microprocessor
640KB system RAM
Realtime clock
Multi-Color Graphics Array
Parallel and serial ports
Mouse interface
Two 720KB 3.5-inch diskette drives
101-key keyboard

Model 30-021: $2,295
All standard features of Model 30-002, except that Model 30-021 has a 720KB 3.5-inch diskette drive and a 20MB hard disk.

Memory capacity on system board
640KB

Expansion slots
Total 8-bit slots: 3
Available slots in minimum configuration: 3

Optional features
Any of the PS/2 monitors
PS/2 Display Adapter: $595
8-MHz 8087 Math Coprocessor: $310
PS/2 Mouse: $95
5.25-inch External Diskette Drive: $395

SYSTEM ARCHITECTURE

The heart of the Model 30 is the Intel 8086 microprocessor. This chip is internally the same as the 8088 processor used in the XT, with two fundamental differences in its interface to the rest of the system: transfers between the processor and memory can be performed 16 bits instead of 8 bits at a time, and the instruction prefetch queue is 6 bytes long instead of 4 bytes. Because the 8086 always fetches instructions in units of a full word (16 bits), its prefetch queue must contain two free bytes before a prefetch is performed.

In the Model 30, the only 16-bit bus is between the processor and the main memory on the system board. All other transfers, whether to disks, I/O ports, or the expansion slots, are performed 1 byte at a time. Even memory-to-memory direct memory access (DMA) transfers are 8-bits wide. Also, any memory in the expansion slots is accessed 8 bits at a time.

Although the 640KB of memory on the system board makes conventional expansion memory unnecessary, the 8-bit data path becomes significant when EMS memory is added. With enhanced EMS (EEMS), backfilling the conventional address space with memory on the EEMS board is often useful.

The clock speed for the processor and the bus is 8 MHz, and memory is accessed with no wait states. An 8086 requires 4 clock cycles to perform memory transfers, resulting in a memory cycle time of 500 nanoseconds (ns). The bus bandwidth is 3.29 times that of an XT, resulting from a clock speed that is 1.68 times faster and a data path that is twice as wide.

Four wait states are inserted into I/O transfers, for a total cycle of 8 clocks, or 1 microsecond. This is approximately the same I/O cycle time as in the XT (5 clocks of 210 ns) and the 6-MHz AT (6 clocks of 167 ns), ensuring that boards designed for the 4.77-MHz XT will work without problem in the Model 30, insofar as transfers to and from I/O ports.

The optional 8087 math coprocessor also runs at 8 MHz. On numeric exceptions, it interrupts the main processor on the nonmaskable interrupt (NMI) line as on the XT, not on interrupt request (IRQ) line 2 via IRQ13, as on the AT. Unlike the XT, however, the Model 30 requires no switch settings to enable the 8087 interrupt.

The system memory resides on the system board in two sections. The first 128KB of RAM consists of four 64K-by-4-bit chips and two 64K-by-1-bit chips (the latter provide the parity bits). These are rated at 150-ns access time and are soldered in. The remaining 512KB is provided by two removable 256K-by-9-bit single in-line memory modules (SIMMs). Each contains three custom memory chips with a bit density exceeding 1 Mbit. The memory map, shown in table 1, is unchanged from that for the XT.

Removing a SIMM from its slot is not difficult once you figure out how, but the proper method is not documented in any of the Model 30 manuals and doing it improperly can damage the retaining brackets. The correct procedure is as follows: using the thumbs, spread sideways the retaining clips at each end of the SIMM board, then rotate the board forward with the forefingers until the holes in the board corners come free of the alignment pins; the board can then be lifted straight out of its slot. To reinstall, insert the SIMM's edge connector into the mating slot with the board tilted forward, then press it back until it clicks in behind the retaining clips.

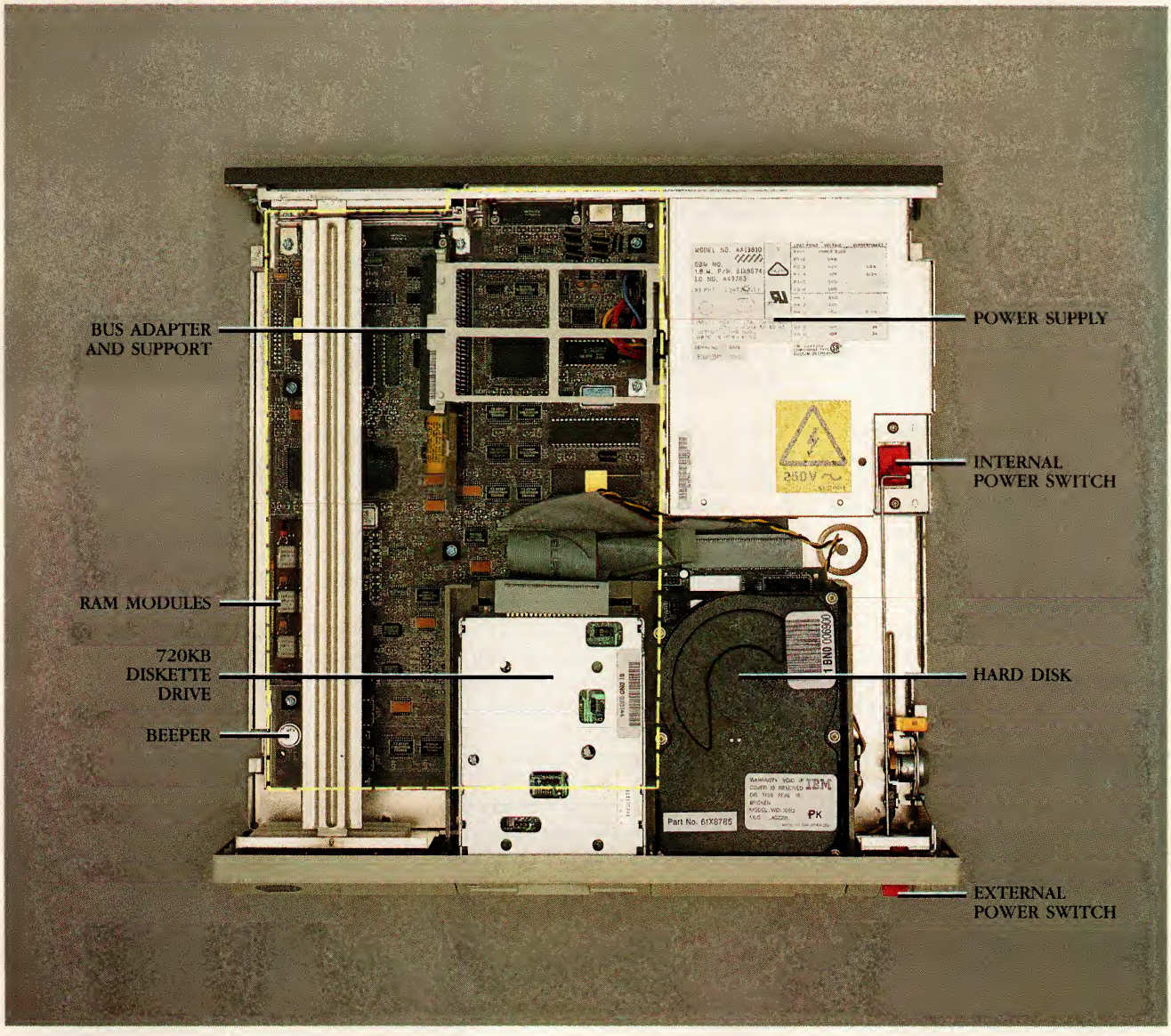
Any 64KB bank of system board memory between 256KB and 640KB is automatically disabled if the power-on self-test (POST) determines that memory at the corresponding addresses exists in the expansion slots. If a failure occurs in the first 128KB, the POST remaps the memory on the SIMMs into the first 512KB of the address space.

The system board carries one connector resembling an expansion slot, except that it contains 80 contacts instead of the usual 62. A bus adapter board, carrying three standard 8-bit expansion connectors and the battery for the clock/calendar, plugs into this socket (see photo 4).

Adapter cards are then plugged horizontally into the slots on the adapter board. Installing adapter cards horizontally is no more difficult than installing them vertically, provided that the slots above the one being filled are empty. Replacing a board in the lower slots requires either removing the boards from the slots above or balancing the system unit on its side. The clock/calendar battery is soldered onto the adapter board; when the battery dies, the entire adapter must be replaced. The instructions for doing this are given only in the hardware maintenance manual that comes with the advanced diagnostics.

The specifications of the I/O channel are identical to those for the PC and XT, and actual tests confirmed a high degree of compatibility. XT option adapters will work if they are capable of operating at the 8-MHz clock speed.

PHOTO 1: *Inside the Model 30 System Unit*



The general layout of the Model 30 is similar to the XT and AT. The pushrod connecting the front-panel power switch to the internal switch on the power supply is visible at the right. The dotted line indicates the location of the system board.

Many of the support chips used on the PC and XT system boards have been replaced with a smaller number of custom VLSI components. The first of these is the System Support Gate Array (SSGA). It is a third bus master (along with the 8086 and 8087) on the control bus, and performs the functions of the bus controller, memory controller, clock generator, and support logic for the DMA controller.

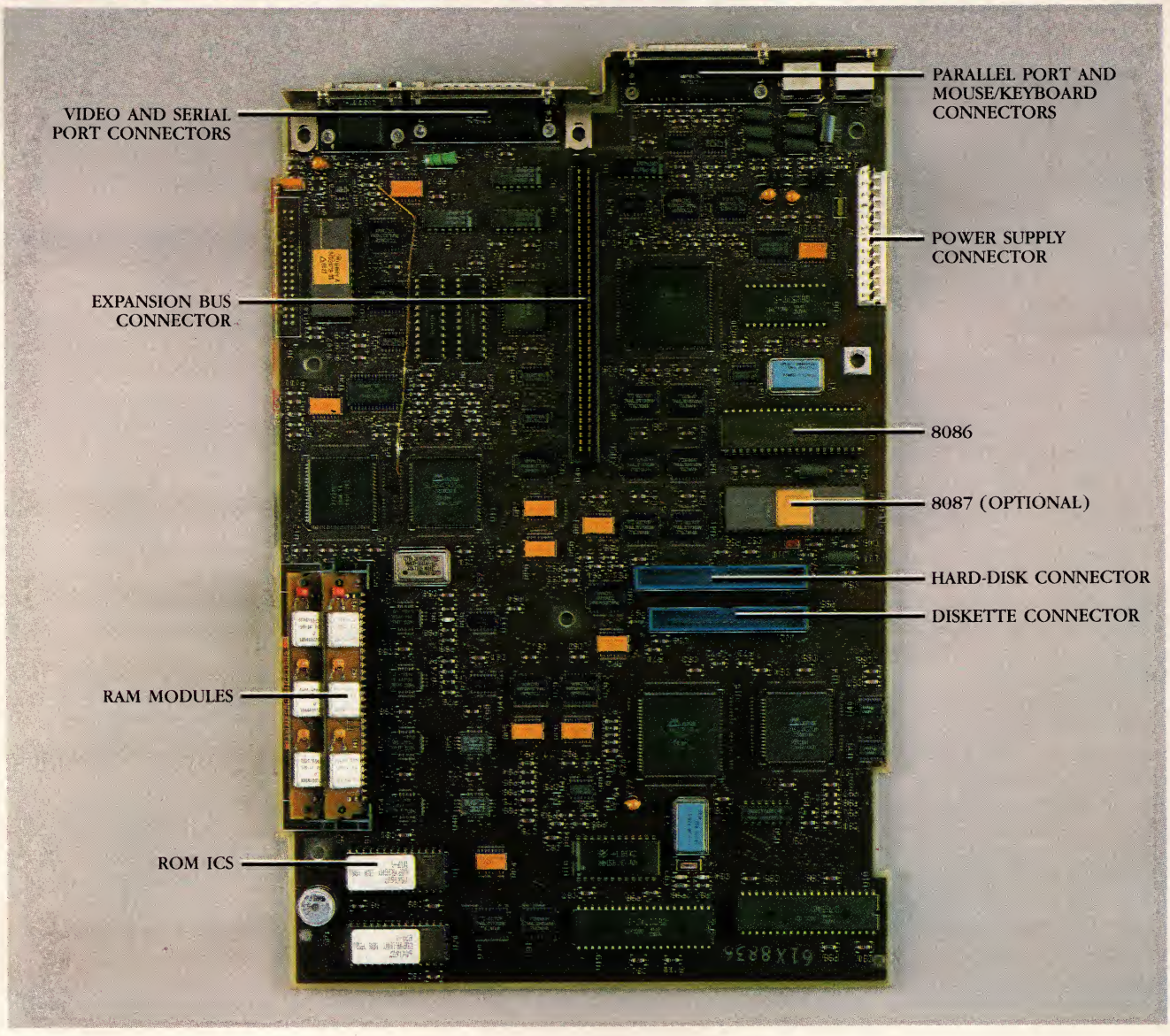
The bus controller mediates bus transfer requests between the microprocessor, the math coprocessor, and the SSGA. The SSGA, which has the highest priority level, seizes the bus in order to perform memory refresh and DMA transfers. It also converts word accesses to I/O ports into two successive byte accesses and inserts wait states as necessary.

The memory controller performs RAM refresh and parity checking. The frequency of refresh is not documented, but assuming that it occurs every 15 microseconds as on all other PC and PS/2 models, the refresh overhead (that is, the bus bandwidth consumed by refresh) can be calculated at 7.5 percent. Another function of the memory controller is to disable system-board memory in case of addressing conflicts and to remap it in case of failure in the lower 128KB, as was mentioned above.

The clock generator takes an input frequency of 48 MHz, which it divides by 6 to produce the 8-MHz processor clock. (On the XT, the 8284 clock generator divides input frequency by 3.) In addition, the generator produces the standard timer signal of 1.19 MHz for driving the time-of-day and tone generation timers.

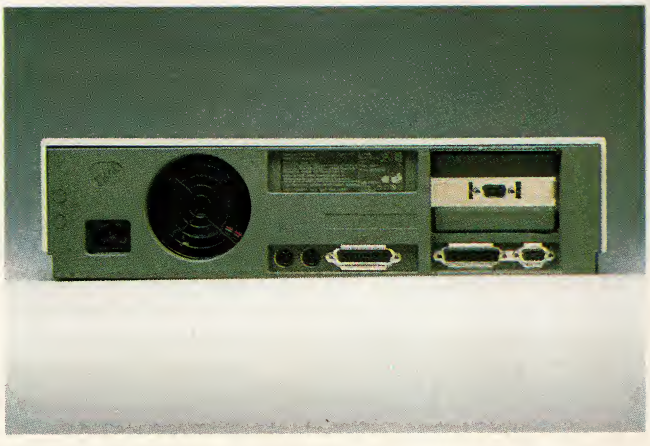
The system timer is an 8253 chip (the same as in the XT) that provides three timer channels. Channels 0 and 2 serve the same functions as in the earlier models; the former generates the timer tick interrupt with a frequency of 18.2 Hz, the latter controls tone generation through the speaker. Channel 1 is reserved for diagnostic purposes. The timing of the memory refresh interval, which is controlled by timer channel 1 in the PC and XT, is performed by dedicated circuitry in the SSGA.

PHOTO 2: *Model 30 System Board*



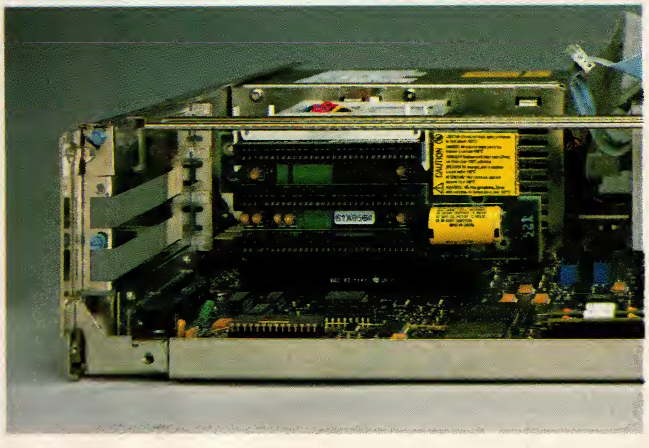
A small number of custom VLSI components, surface-mounted chips, compact memory packaging, and off-board expansion slots result in a system board that is quite a bit smaller than the XT's, yet incorporates many more features.

PHOTO 3: *Rear of Model 30 System Unit*



The connectors to the right of the fan opening are for the keyboard, mouse, parallel port, serial port, and video.

PHOTO 4: *Bus Adapter Board*



The bus adapter, which plugs into an 80-pin slot, carries three standard 62-pin slots and the clock/calendar battery.

The DMA controller is an 8237 chip, again the same one that is used in the PC and XT. It provides four channels of DMA, with channel 3 assigned to the hard disk, channel 2 to the diskette, and channel 1 unassigned and available for use by programs. The purpose of channel 0 is not documented; it is not used for generating memory refresh requests, which are handled by dedicated circuitry in the SSGA. DMA is a potential bottleneck to system throughput, because transfers are performed 8 bits at a time.

Another VLSI chip, the I/O Support Gate Array (IOSGA), incorporates the functions handled in the XT by the 8259 interrupt controller, the 8255 peripheral interface, and the 8042 keyboard controller. In addition, this array can disable the on-board peripherals—that is, the built-in controllers for the disks, video, serial port, and parallel port. When a particular peripheral on the system board is disabled, references to its I/O addresses are routed to the expansion slots. This provides a software-controlled method of replacing the built-in controllers with others in the expansion slots.

The interrupt controller incorporated into the IOSGA supports the same eight prioritized levels of interrupts as does the 8259 chip in the XT. The interrupt assignments, listed in table 2, are also unchanged. To maintain compatibility with existing XT expansion boards, interrupts are edge-triggered, instead of level-triggered as in the other PS/2 models. The documentation of the interrupt controller function is essentially identical to that for the 8259 controllers in the *AT Technical Reference*, although the degree to which the IOSGA emulates an 8259 is not specifically stated.

Another interrupt-related function of the IOSGA is to generate an NMI on any of three conditions: memory parity error on the system board, exception interrupt from the 8087, or a high level on the I/O channel check signal from an expansion slot (intended to indicate a parity error on an expansion board). As in the PC and XT, the source of the NMI can be determined by testing bits in I/O port 62H.

The I/O devices on the system board require that the IRQ lines allocated to them be present on the system board. As a result, the allocation of hardware interrupt lines between the system board and the I/O channel is different than in the PC and XT. IRQ levels 0 and 1 (timer tick and keyboard) are present only on the system board, while IRQ3 (normally used by the second serial port) is found only in the expansion slots.

TABLE 1: *System Memory Map*

HEXADECIMAL ADDRESS	LENGTH	FUNCTION
00000–9FFFF	640KB	User read/write memory
A0000–BFFFF	128KB	Video buffer
C0000–EFFFF	192KB	Reserved for ROM on adapters
F0000–FFFFF	64KB	System ROM

The layout of memory is unchanged from the standard set in the original IBM PC.

The lines for the other five interrupt levels are switched by the IOSGA between the system board and the I/O channel, depending on whether the standard built-in ports are activated or not. Therefore, a device on an adapter cannot share an interrupt level with a device on the system board. (Sharing of hardware interrupts is described in the *Technical Reference* in the same way as for the AT.)

The keyboard controller component of the IOSGA replaces the 8042 controller used with the 101-key keyboard in an AT. Although it provides a similar functionality, the implementation is different, and programs that communicate directly with the 8042 instead of using the BIOS interface do not recognize the keyboard as AT-compatible. The low-level interface to the keyboard is not documented, so programs are limited to what is available through the BIOS interface.

The functions of a diskette controller are provided by another VLSI chip on the system board. It emulates the NEC 765 diskette controller used on the XT and AT, supports a disk change signal as does the AT controller, and adds two more registers that indicate the status of various signals that are sent by the controller to the drives. The controller is perfectly capable of supporting the 1.44MB drives used on the other PS/2 models (the specifications for the diskette controllers are virtually identical across the PS/2 line), but at each disk access, the BIOS programs it to operate in 720KB mode.

The hard-disk controller is not incorporated on the system board, but attached to the hard-disk drive. It connects via a ribbon cable to what is in essence an expansion slot dedicated to the hard disk—it supports signal lines for only one IRQ level and one DMA channel. The controller itself is functionally identical to the one in the XT.

The printer port is at I/O address 378H, which in previous machines was defined as LPT1 unless a graphics adapter with a printer port occupied address 3BCH. It differs from the standard printer adapter in that it is bidirectional, meaning that its primary data latch can be set either by the processor (with an OUT instruction to address 378H) or by the device attached to the port. The direction of input to the data latch is set by a bit in a control port of the SSGA. The bidirectional feature is used by IBM's Data Migration Facility, a parallel-port equivalent to the null modem, in order to send data from one computer to another. Because the printer ports on older models are output-only devices, this facility can send data only to a PS/2 machine.

TABLE 2: *Interrupts*

LEVEL	ASSIGNMENT
NMI	Parity check, coprocessor, I/O channel check
IRQ 0	System timer
IRQ 1	Keyboard, mouse, realtime clock
IRQ 2	Video
IRQ 3	Unassigned (usually used by COM2)
IRQ 4	Serial port (COM1)
IRQ 5	Hard disk
IRQ 6	Diskette drive
IRQ 7	Parallel port

Eight levels of hardware interrupts are implemented in custom silicon by an interrupt controller functionally similar to an XT's 8259 chip.

The serial port is no different than the one in the XT. It resides at I/O address 3F8H (which makes it COM1), is implemented with an 8250A Asynchronous Communications Controller, and supports transfer rates from 50 to 9600 bps. The clock for timing the transmission rate is provided by the system clock generator in the SSGA. Both the parallel and serial ports can be disabled, but they cannot be remapped to different I/O addresses.

The I/O address map is shown in table 3. Except for the ports within the two new support arrays, the assign-

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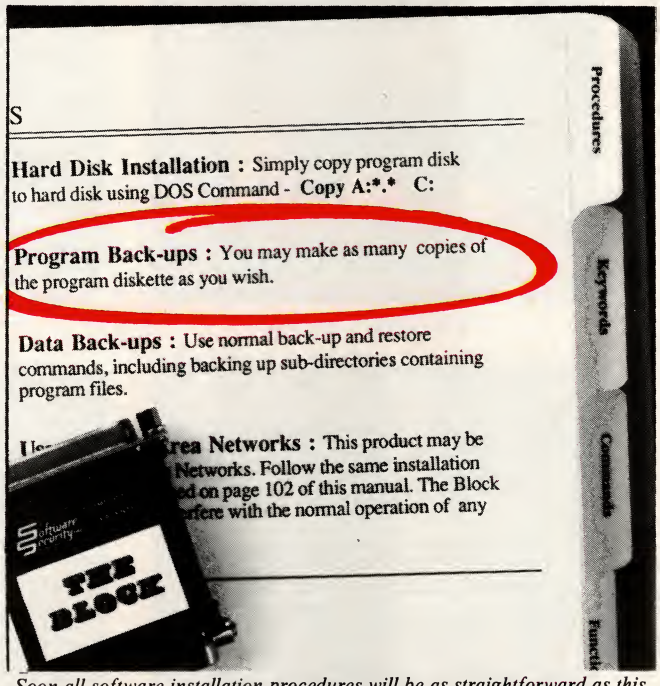
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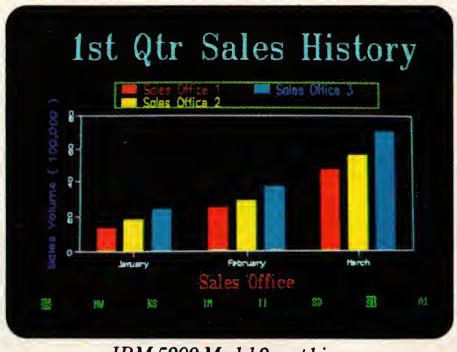
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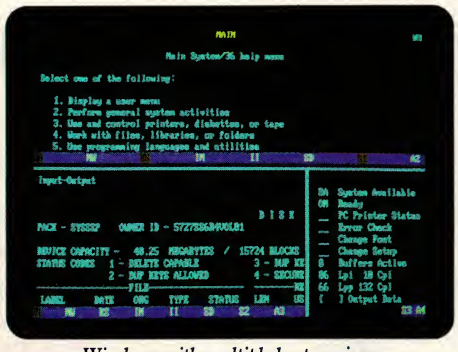
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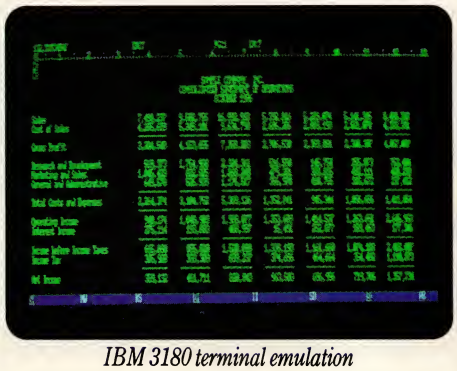
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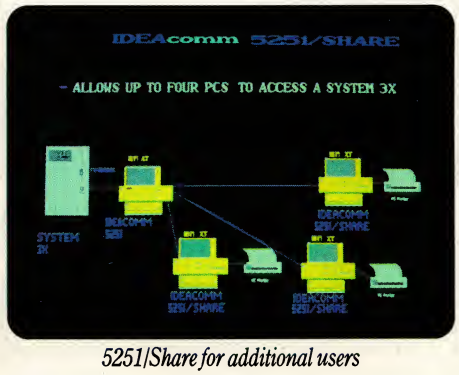
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TABLE 3: *I/O Address Map*

HEXADECIMAL ADDRESS	DEVICE
000–01F	8237 DMA controller
020–03F	IOSGA: interrupt controller
040–05F	8253 timer
060	IOSGA: keyboard input port
061–062	IOSGA: speaker and configuration control
063–06A	SSGA: (undocumented)
06B	SSGA: RAM enable/remap
06C–06F	SSGA: (undocumented)
080–08F	SSGA: DMA page registers
0A0–0AF	IOSGA: NMI enable
0B0–0BF	Realtime clock/calendar (undocumented)
0E0–0EF	Realtime clock/calendar (undocumented)
320–32F	Hard disk
378–37F	Parallel port
3C0–3DF	Video subsystem
3F0–3F7	Diskette drive
3F8–3FF	Serial port

IOSGA = I/O Support Gate Array
SSGA = System Support Gate array

Most port assignments in the VLSI gate array support chips are undocumented.

ments follow established practice. Ports at addresses below 100H are reserved for the system board, and higher addresses are available in the I/O channel. Only ports up to 3FFH are defined, because the Model 30 must accommodate PC adapter boards that do not distinguish higher addresses.

The system ROM consists of 64KB in the highest segment of the address space, beginning at segment F000H. It is implemented by two 32K-by-8-bit chips. The entire segment is populated, and the system board makes no provision for adding ROM, as can be done in the AT. As is apparent in the memory map shown in table 1, additional ROM addressed between C000H and F000H can be added on adapters in the expansion slots.

The system BIOS contains the POST and hardware interface routines for all devices supported on the system board except the mouse, which requires the loading of a RAM-resident device driver at system initialization time. Most of the services available in the other PS/2 models, except those that are related to protected-mode operation, are present. In this respect, the Model 30 is fully up to date.

The BIOS data area, originally 256 bytes at segment 40H, has been extended by 1,024 bytes. This extension is allocated at the high end of memory, just below the top of physical memory. Therefore, the total memory available, as reported by CHKDSK, is reduced by 1KB—on a 640KB system, CHKDSK reports 639KB. This reduction might be disconcerting to the user, but it is really no more significant than increasing the system's use of low memory, which has been done with every update to the operating system. The net effect is the same: a reduction in the bottom-line "bytes free."

What is significant is the location of this data area. In the past, the top of memory was fair game, and some ill-behaved programs used it without asking DOS for permission. To some extent, DOS sanctions this behavior by cleaning up after such programs and reloading the transient portion of COMMAND.COM if the top of memory gets trashed. But the integrity of the BIOS data areas depends only on the strict adherence to the rules of memory allocation. Programs that use memory limits as reported by the hardware, not by DOS, can crash a PS/2 system.

For the Model 30, the extended data area is used in support of the mouse. It contains a far pointer to the mouse device driver and two bytes of flags containing various status indicators. For the PS/2 Models 50, 60, and 80, the use of the extended data area is not documented.

A pointer to the extended BIOS data area is kept in the standard data area at location 40:0EH. In previous models, this word had been reserved for the address of the fourth parallel port, but neither BIOS nor DOS ever supported four printers. On all PS/2 models, the System Services interrupt 15H also provides a function that returns this pointer.

SETTING UP

Installation of the system is quite straightforward, because no switches need to be set. In fact, because all the necessary peripheral support is built in, the user does not even have to open up the case during the installation process. Besides power cords, only two connections are necessary: the keyboard and monitor. Although the installation instructions specify which of the two identical receptacles on the back panel the keyboard should be plugged into, in fact they are interchangeable. Both keyboard and mouse operate equally well through either connector.

At boot-up, the POST routines test both ports and record which is which in the SSGA. Communicating with the keyboard and mouse therefore requires obtaining the address of the proper port from the SSGA, but the location of this information and the means of obtaining it are not documented.

Initial boot-up can be accomplished with either a DOS diskette or the Starter Diskette supplied with the system. The Starter Diskette contains two main programs: an illustrated "tour of the system" that explains the various system components; and Services, which provides the standard set of diagnostics, disk copying, and formatting functions. The user interface presents the familiar monochrome pick-by-number menus of the IBM diagnostics diskette for its older models, rather than the colorful point-and-shoot windows of the configuration program on the other PS/2 machines. The Model 30 diagnostic tests include a check-out of the new video modes of the MCGA.

Because the Model 30 does not store any configuration information, it does not need a SETUP program. Although in DOS 3.3 the TIME and DATE commands affect the clock/calendar, they do so only if the clock is already initialized. Initializing it, say after the battery has gone dead, still requires a special program provided only on the Starter Diskette.

On a system that has no hard disk, booting the computer without a diskette in drive A: produces an animated display that graphically requests the user to insert a diskette and press the F1 key, as on the IBM Convertible. Pressing F1 without inserting a diskette invokes Cassette BASIC, which no longer comes up automatically if the

system is booted with drive A: empty and no bootable hard disk.

The key lock on the right side panel of the system unit takes the same type of cylindrical key as the AT. The lock also operates in the same manner as on the AT; it secures the system unit cover and activates a switch that disables the keyboard. In contrast, the locks on the other PS/2 models secure the case only, and keyboard security is provided through software.

The system unit cover is held on with four screws, two on each side of the case. Unlike the cover screws of the Model 50, which can be turned by hand, and the fasteners of the Models 60 and 80 covers, which are turned by a coin, the Model 30 fasteners require a screwdriver. As on the other PS/2 models, the screws remain attached to the cover after it is removed.

The cover is removed by sliding it backwards about one-half inch and lifting straight up. This makes opening the case more convenient than on previous models, because the keyboard need not be moved from in front of the Model 30. The cover is made of plastic but is lined with aluminum sheet stock for containing radio frequency emissions. The chassis, however, is all-metal construction. The plastic front panel is permanently attached to the chassis and does not come off with the cover.

Inside the system unit, the most eye-catching feature is the push-rod connecting the front-panel power switch to the power supply at the right rear of the unit. This mechanism ensures that, for the safety of operators and especially installers of expansion cards, AC line voltage stays within the power supply enclosure. The 70-watt power supply feeds power to the system board through two multiwire connectors, just as in the PC and XT. Given the low power consumption of the many CMOS components on the system board, and the fact that power-hungry options such as accelerator boards and hard-disk controllers will not be installed, the output seems adequate. The test unit had no problems powering 2MB EMS boards, along with the controller for an external diskette drive and the PS/2 Display Adapter.

EXPANSION OPTIONS

Although the Model 30 comes fully equipped with all necessary features, many users will want to add extras. Because of its standard 8-bit PC bus, all PC and XT expansion boards will fit and most should work properly. During testing, any problems that were encountered were due to the higher clock speed of the Model 30.

One desirable option is the PS/2 Display Adapter, which provides the Model 30, and any standard PC-bus machine, with full VGA capabilities.

Another option specific to the PS/2 line is the 5.25-inch External Diskette Drive. Its half-length interface board plugs into an expansion slot and mates with the drive B: connector of the ribbon cable from the system board diskette controller. The ribbon cable connector is not keyed (unusual for IBM equipment), but the pins are plainly marked on both mating pieces. The drive unit's cable (permanently connected at the drive end) plugs into the 37-pin DB connector on the board's bracket. The drive unit has its own power supply and AC power cord.

The external diskette drive operates as a normal B: drive with 360KB capacity. For the drive to be recognized, it must be turned on before the system unit is powered up—otherwise the internal drive acts as both A: and B: drives. Overall, its installation and operation are troublefree. Reading, writing, and formatting were performed without incident. Its major disadvantage is its huge size—about equivalent to the size of an IBM Convertible. A second drawback is the long time needed to detect read errors. Whereas DOS can detect an empty internal drive in only 2.5 seconds, it takes 19 seconds to figure out that the external drive is empty and an unreasonable 2.5 minutes to detect that the drive is not powered. In the latter case, the user may well conclude that the system has crashed, although this situation occurs only if power to the drive has been turned off after the system is running.

One desirable option is the PS/2 Display Adapter, which gives the Model 30, and any standard PC-bus machine, full VGA capabilities.

The Model 30's mouse port accommodates only a PS/2 mouse; models are currently available from IBM, Microsoft, and Logitech. The Microsoft Inport Mouse cannot be plugged into this port because the number and arrangement of pins are different. However, a bus mouse can be used with its own controller board, and a serial mouse can plug into the serial port.

TWICE AS FAST

The Model 30 was tested for compatibility and performance using *PC Tech Journal*'s standard battery of hardware and software tests, developed for evaluating AT-compatible machines. (See "Out from the Shadow of IBM . . . ," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52 and "Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 70.) Hardware tested included the PS/2 Display Adapter, which provides the Model 30 with VGA capabilities, IBM and Microsoft mice, the PS/2 5.25-inch External Diskette Drive, EMS memory boards from Intel and AST, and the Hayes 1200B internal modem.

With the display adapter installed, the system's video behavior is identical to that of the Model 50. BASIC programs can use the EGA screen modes, and Microsoft Word version 3.1 has the same problems as it does on the Model 50 (see software tests below). Because no software has yet been developed to take advantage of these capabilities, at present the only reason to install this adapter is to provide EGA compatibility at the BIOS level. Without the adapter, most software treats the native MCGA circuitry as it would a CGA.

Three different types of mice were successfully tested with the Model 30: an IBM PS/2 mouse connected to the mouse port, a Microsoft serial mouse connected to the serial port, and a Microsoft bus mouse connected through its dedicated Inport controller (which takes up an expansion slot). All three worked with Microsoft Word and with the mouse menus supplied by Microsoft. IBM's mouse driver is a .COM file that is typically run from AUTOEXEC.BAT, whereas the Microsoft mice use a MOUSE.SYS device driver loaded by CONFIG.SYS. Nevertheless, the driver software is interchangeable among all three hardware models.

Because the Model 30 already has 640KB of memory on the system board, the only useful memory expansions are EMS boards. Three such boards were tested, and two of them worked well. An early-model Intel Above Board with 200-ns chips booted up properly, but data errors began occurring as the system warmed up. This was manifested by file allocation errors and eventually loss of the file allocation table on a RAM disk in expanded memory. Intel

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In addition to the larger address space offered by protected mode, OS/386 adds 32-bit performance to systems like the Compaq™ 386 which, until now, have been shackled to 8086 emulation.

Dhrystone Benchmarks	Microsoft C 16-bit	High C OS/386 32-bit	Scale
IBM AT 6Mhz	793	na	1.0
Compaq 386-16Mhz	2,380	5,837	7.3
HummingBoard-16Mhz	2,777	6,718	8.5
HummingBoard-20Mhz	3,571	8,470	10.7
Vax 8600 (Unix 4.3 BSD,cc)		6,423	8.1
Sun 3/160 (Sun 4.2 3.0A,cc)		3,246	4.1

OS/386 can be customized to give unmodified DOS programs up to 900k on 386 systems, regardless of how many TSR's, networks, disk caches, etc., are installed.



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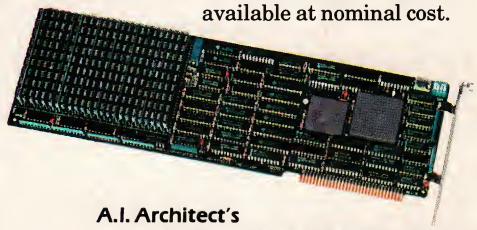
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does not guarantee its early models at 8 MHz and recommends the new Above Board 286 for the Model 30. One of these, with 150-ns memory chips, worked flawlessly. The AST RAMpage! with memory chips rated at 150 ns also worked with no problems. These results do not mean that EMS boards work at 8 MHz as long as their memory chips are rated at 150 ns or faster. The other components on the board, such as logic gates and I/O ports, must also be capable of operating at the system clock rate.

A Hayes 1200B internal modem was installed and configured as COM2; it operated well with three different communications programs: Hayes Smartcom II, DCA/Crosstalk Communications' Crosstalk XVI, and Datastorm Technologies' PROCOMM.

Software compatibility was tested with a variety of commercial applications: Microsoft Word, Lotus 1-2-3, Fifth Generation Systems' Fastback, Ashton-Tate's dBASE III PLUS, and Borland's SideKick and SuperKey. With one exception, no problems were encountered with any of the programs, including the highly hardware-specific Fastback. This indicates a high level of hardware compatibility with the PC standard.

The only problem encountered was between Microsoft Word version 3.1 and earlier and the PS/2 Display Adapter; Word came up in cyan on blue and did not allow changing colors. The same behavior was noted on the other PS/2 models. The newer version 3.11 works properly, using the EGA color scheme. Word treats the MCGA as a CGA: graphics mode is displayed in black and white only, while text mode can display any of the 16 CGA background colors (Word disables foreground blinking, thus allowing high-intensity background colors).

Model 30 performance was tested with two sets of programs. First, the *PC Tech Journal* Evaluation Suite for AT compatibles was used for some basic measurements; however, because these tests are designed to measure 286 and 386 processors, they were supplemented with a second set of measurements developed for evaluating accelerator boards (see "Speed Infusion," Ted Mirecki, February 1987, p. 126). These tests were designed to demonstrate the improvement provided by 16-bit processors running at high clock rates over the performance of an 8088-based XT running at 4.77 MHz.

One of the tests measured bus bandwidth by timing the execution of a straight-line sequence of instructions with an execution time shorter than the prefetch time. The total execution time of the sequence therefore equaled the time required to transfer a known amount of data on the bus.

The assembler test used Microsoft MASM 4.0 to assemble the VDISK device driver supplied with DOS 3.2. (The VDISK.LST file was converted into source form with a BASIC program presented in "Same Language, New Architecture", Ted Mirecki, October 1985, p. 48.) To avoid dependencies on disk performance, the assembler, source file, and object file output were all on a RAMdisk in expanded memory.

In the spreadsheet test Lotus 1-2-3 calculated a loan repayment table for 80 different interest rates and 30 terms, using the Data Table 2 command.

A test was borrowed from *PC Tech Journal*'s standard application for testing data managers (see "Evaluating Data Managers as Development Tools," Julie Anderson, August 1985, p. 46). It involved using dBASE to sort an author file containing 900 records of 353 bytes each; the sort was done on three fields (ZIP, LAST_NAME, FIRST_NAME) totaling 35 bytes. The input and output files were on hard disk, so this test measured the performance of the disk as well as the processor.

The word processor test used Microsoft Word to repaginate a 19-page, 57KB document. The document and the word processor's scratch files resided on hard disk. This was the only test timed with a stopwatch; all others used the system timer.

Table 4 lists the timings for all of these performance tests, with comparisons to both an XT and an AT. In general, the results bear out IBM's claim that the Model 30 is about twice as fast as an XT. The hard disk, although not

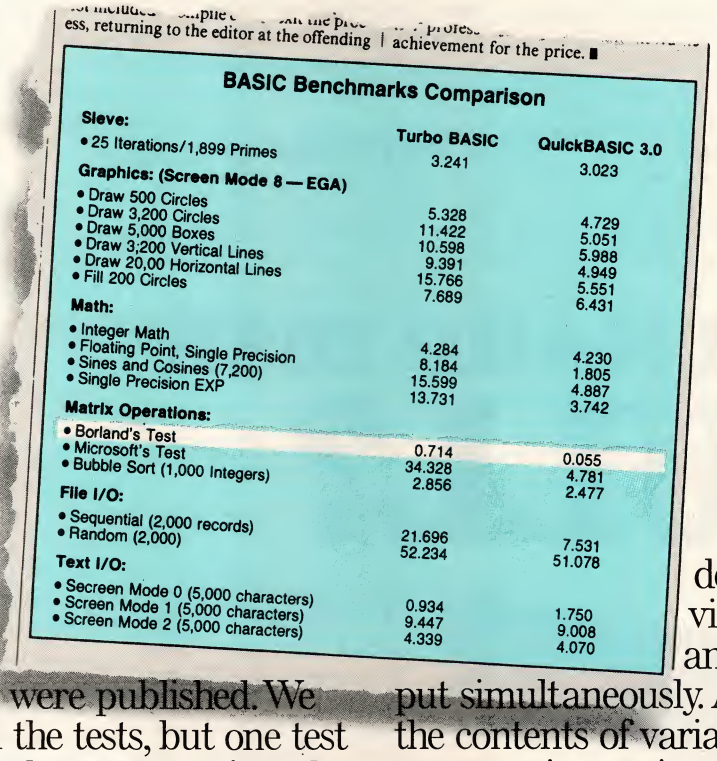
TABLE 4: *Compatibility and Performance Tests*

	4.77-MHz XT	8-MHz AT, 30MB DISK	8-MHz MODEL 30
ATBIOS			
ROM BIOS date	8/16/82	11/15/85	9/2/86
ATPERF			
Average RAM instruction fetch (μs)			
BYTE	0.92	0.25 (368)[a]	0.27 (341)
WORD	1.83	0.4 (458)	0.55 (333)
CPU clock rate (MHz)	4.77	8.0 (168)	8.0 (168)
Math coprocessor clock rate (MHz)	4.77	5.3 (111)	8.0 (168)
RAM wait states	0	1	0
ATFLOAT			
Performance as percentage relative to XT	100	183	190
ATDISK			
Sectors/track	17	17	17
Heads	4	5	4
Cylinders	304	731	610
Total space (MB)	10.58	31.81	21.24
Track-track seek time (ms)	18.0	6.0	16.7
Average seek time (ms)	84.2	37.1	83.5
Effective transfer rate (KB/sec)	84.8	170.1	127.0
DOS file I/O (sec)	26.7	7.3 (366)	16.5 (162)
BUSPERF			
Bus bandwidth as percentage relative to XT	100	451	329
APPLICATION TESTS (sec)			
Assembly	34	9 (387)	15 (227)
1-2-3 spreadsheet recalculation	41	10 (410)	35 (117)
dBASE III sort	119	60 (198)	87 (137)
Word repaginate	50	13 (385)	21 (238)

[a] *Figures in parentheses are percentages relative to the XT.*

The Model 30, with its 8086 processor and 8-bit bus, is an XT-class machine; its performance bears out IBM's claim of a twofold improvement over an XT. The only test in which it outperforms an AT is real-number processing (ATLFOAT).

Microsoft QuickBASIC 3.0's speed was verified by an indisputably independent test.



ess, returning to the editor at the offending | achievement for the price. ■

BASIC Benchmarks Comparison

	Turbo BASIC	QuickBASIC 3.0
Sieve:		
• 25 Iterations/1,899 Primes	3.241	3.023
Graphics: (Screen Mode 8 — EGA)		
• Draw 500 Circles	5.328	4.729
• Draw 3,200 Circles	11.422	5.051
• Draw 5,000 Boxes	10.598	5.988
• Draw 3;200 Vertical Lines	9.391	4.949
• Draw 20,00 Horizontal Lines	15.766	5.551
• Fill 200 Circles	7.689	6.431
Math:		
• Integer Math	4.284	4.230
• Floating Point, Single Precision	8.184	1.805
• Sines and Cosines (7,200)	15.599	4.887
• Single Precision EXP	13.731	3.742
Matrix Operations:		
• Borland's Test	0.714	0.055
• Microsoft's Test	34.328	4.781
• Bubble Sort (1,000 Integers)	2.856	2.477
File I/O:		
• Sequential (2,000 records)	21.696	7.531
• Random (2,000)	52.234	51.078
Text I/O:		
• Secreen Mode 0 (5,000 characters)	0.934	1.750
• Screen Mode 1 (5,000 characters)	9.447	9.008
• Screen Mode 2 (5,000 characters)	4.339	4.070

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intrinsically faster than the one in the XT, is matched to the faster processor by a lower interleave factor: 3 instead of 6 on the XT.

MANUAL DEPARTURE

The only documentation packed with the Model 30 is a 70-page *Guide to Operations* that describes the unpacking and set-up of the system. It is similar to the manuals supplied with previous models. One minor inconvenience is the fact that the booklet is not hole-punched, so it cannot be placed in a binder along with the instruction pamphlets that come with each option board. As with recent XT and AT models, the BASIC manual is not supplied with the system unit and must be purchased at added cost.

The *Technical Reference* manual, available for $75, is a departure from previous manuals of this type. It contains no BIOS listings or logic diagrams, but timing diagrams for the bus have been added. Although maintaining the concept of open architecture in the PS/2 line, IBM is giving minimum aid to manufacturers of compatibles.

The contents of the manual indicate that it is undergoing a transition. Certain sections are carried over from *Technical Reference* manuals for previous models, but lack information specific to the Model 30. For example, the description of hardware interrupt sharing is copied verbatim from the *AT Technical Reference*, but no documentation is included for the commands recognized by the interrupt controller. Although previous manuals did not cover the controller, they at least specified the type (one or two Intel 8259 chips), so full documentation could be obtained from Intel. In the Model 30, however, the functions of the controller are implemented in custom silicon.

The BIOS section of the *Technical Reference* contains no listings, only the interface specifications. In this regard, the Model 30 *Technical Reference* is more complete than those for the other PS/2 models, which contain no BIOS information whatsoever. The BIOS for these models is covered in a separate $75 manual, the *BIOS Interface Technical Reference,* which contains BIOS information for *all* IBM desktop models from the original PC, including the Model 30.

PUTTING IT IN PERSPECTIVE

When viewed from the proper perspective—that is, as an XT replacement rather than as a full-fledged member of the PS/2 family—the Model 30 is quite impressive and should earn a place in today's market.

If the machine is not a clearcut PS/2, how does it fit into IBM's product line? The target markets for an entry-level machine such as this are small businesses with modest requirements and budgets; larger businesses that want to supplement more powerful desktop systems with a low-end machine for applications that do not put great processing demands on a system; education; and home use.

The Model 30 is well suited for two of these markets. In education and in small businesses—or in any situation in which the computer is used in stand-alone mode and does not need to interface with more powerful systems, the Model 30 certainly fits the bill. As a support machine, however, either at work or at home (where computers are increasingly used for work brought home from the office), the Model 30 falls short on two counts. First, it is unable to migrate to a protected-mode operating system, and second, it has incompatible recording media (while this can be overcome, it is nonetheless an inconvenience).

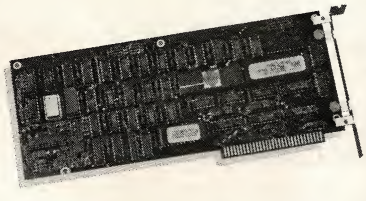
In the areas of video capabilities and price, the Model 30 also comes up wanting. The best that the MCGA is capable of (320-by-200 resolution and 256 colors) is adequate for the applications that might be run on a machine of this type, but these capabilities are unique to this model. It is therefore unlikely that many applications will be written specifically for this narrow market, just as few were tailored to the unique capabilities of the PC*jr*. Standard applications treat the MCGA as a CGA, and that is simply insufficient. VGA capabilities can be added by installing the PS/2 Display Adapter, but that increases the already substantial cost of the Model 30.

In a minimal practical configuration, with hard disk and monochrome monitor, the Model 30 lists for $2,545. Although this is less than the list price of a similarly equipped XT, it is more than twice the street price of a compatible machine.

Given its features, quality, and brand name, the Model 30 could easily become a viable alternative to the XT—perhaps with a price cut and some aggressive discounting. On the expectation that DOS 3.3 will remain in use for the foreseeable future, XT-class machines are likely to have a long and useful life, and the Model 30 can play a significant role in markets that value quality over price.

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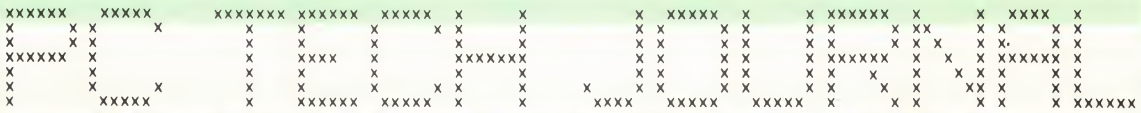
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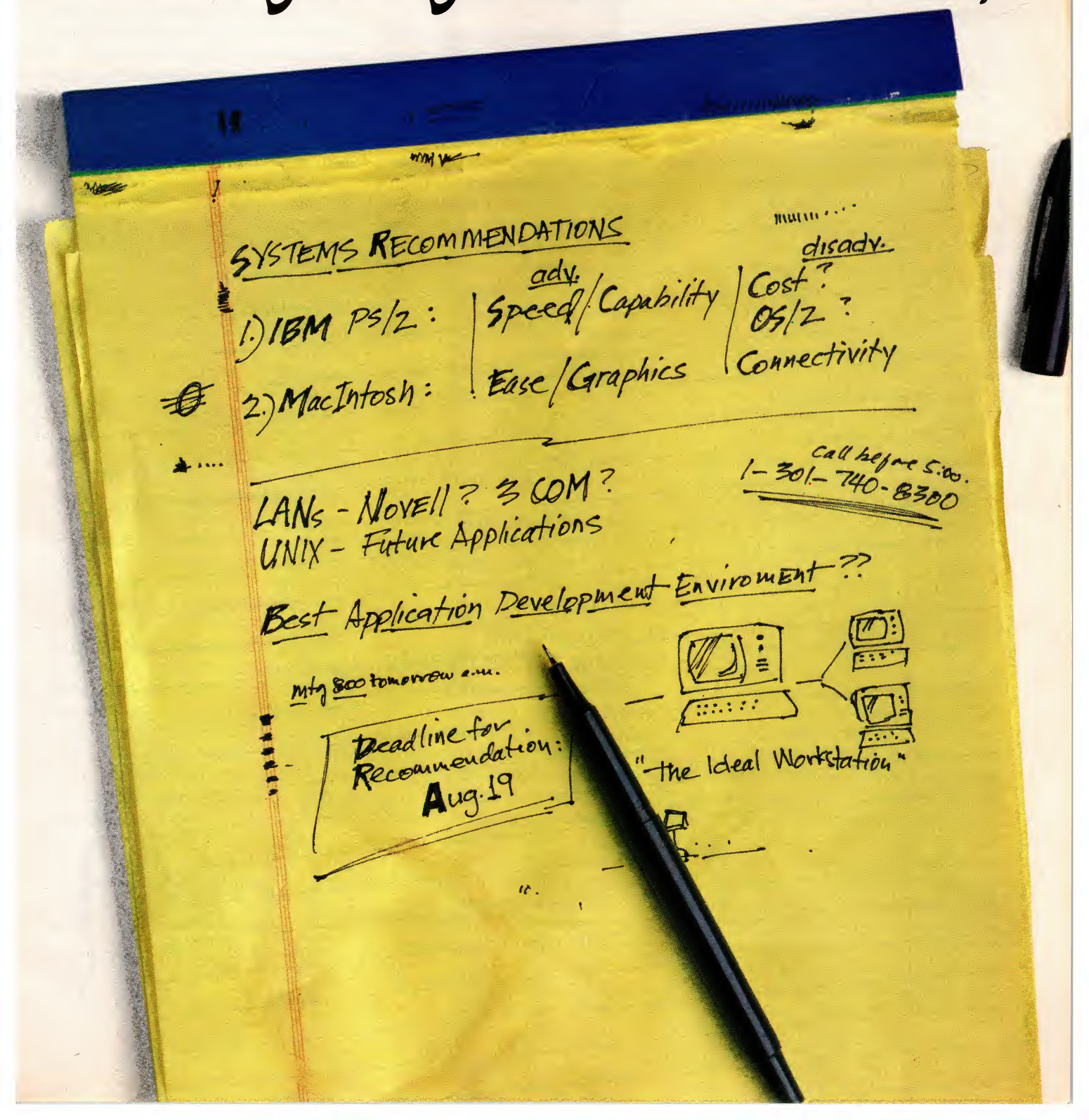
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1. PS/2: Rebirth of the IBM Standard. This timely discussion will tackle systems integretation issues surrounding IBM's PS/2, including the new microchannel bus, 3½" diskette, graphics standard and communications capabilities.

2. The Rise of The Macintosh Standard. The resurgence of an alternative standard: Learn about the Mac's 32-bit architecture, open design, windowing, and inherent friendliness—as well as its future in the corporate world.

3. Implications of OS/2: Operating System of the 1990s? The pros and cons of the new IBM operating system will be reviewed, including insight on its speed, multitasking abilities and compatibility box.

4. Waiting for OS/2: Alternative Operating Systems. A new generation of multitasking/ multiuser operating systems is arriving for the PC. OS/2 is announced but undelivered. It's appropriate to examine alternatives such as UNIX, DESQVIEW, PC-MOS and others. Learn more about standards, options and implications at this panel discussion.

5. Applications Development. Beyond 3rd Generation towards AI: Learn how different the new object-oriented/AI languages are from COBOL, FORTRAN, C, BASIC, etc., and how user companies are building AI/expert systems.

6. Developing Applications in a Multiuser/Multivendor Environment: When more than one type and size of machine are in the picture, optimizing performance is tricky. Put the pieces together at this timely discussion.

7. Optimizing LAN Performance. Careful LAN selection and implementation is the name of the game in networking. This highly relevant session will help you fine-tune your LAN smarts.

8. Linking Unlike Machines. IBM has some planned solutions, but what are users and vendors doing right now about connecting diverse systems? Find out by attending.

9. Database Management on LANs. Although a major theoretical benefit of local area networks is the use of shared databases, lots of real world obstacles stand in the way. Find what you need to know about the problems and the solutions to LAN-based data management.

10. The Desktop-based DBMS as a Production Database. Most PC-based data management software is used primarily as a decision-support tool. But the best of the database management products offer multiuser, transaction processing capabilities. Learn which products deliver in this discussion.

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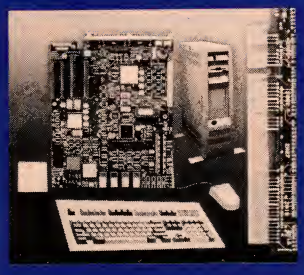
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#2	Rise of the MacIntosh Standard	J.B. Leep, Business Land Charles Oppenheimer, Apple Jack Bauman, Hughes Aircraft
#3	Implications of OS/2	Steve Ballmer, Microsoft Alan Ashton, WordPerfect Mike Swavely, Compaq
#4	Alternative Operating Systems	Chuck Hickey, MicroPort John White, Interactive Systems Mike Johnson, TransDK, Inc.
#5	Applications Development	Eugene Wang, Gold Hill Philippe Kahn, Borland Ted Markowitz, Amex. Exp.
#7	Optimizing LAN Performance	Craig Burton, Novell Bob Metcalfe, 3COM Lauri Autonell, Merrill Lynch
#9	Data Management on LANS	Rick Watkins, Accelerated Learning Center Richard Schwartz, Ansa Tom Rhinevtson, Softcraft
#10	Desktop-Based DBMS as a Production Database	Bob Epstein, SyBase Randy Livingstone, RTI Bill Casey, Cullinet

PORTRAITS OF THE



PERSONAL SYSTEM/2



PS/2 Model 50



PS/2 Model 60

Models 50 and 60: The New-Generation ATs

Models 50 and 60 are the middle siblings in the PS/2 family. In terms of capability and performance, these 80286-based machines are new-generation ATs.

JIM SHIELDS

New generation or not, some will say, an 80286 running at 10 MHz is still an 80286. Indisputable as that is, identifying the IBM Personal System/2 Model 50 and Model 60 as new-generation PC/ATs does not diminish their flexibility, reliability, and performance. Indeed, these two models in the PS/2 line improve handsomely on the tradition established by the AT.

In the most obvious realignment, AT-level proficiency can now be had in two distinct configurations. The desktop Model 50 offers minimal mass storage and expandability, but it will serve well as a medium-performance, personal productivity workstation, particularly in a networked environment. The Model 60, a larger, floor-standing unit, delivers mass storage, memory, and device expansion capability suitable for employment as a network server or small multiuser host system. Although they share many capabilities, the achievement in these machines lies in their tailoring to different situations.

Common to both is the 10-MHz 80286 and the 10-MHz, 16-bit implementation of the new Micro Channel bus architecture. The 80286 of the AT Model 339 runs at 8 MHz. An optional 80287 math coprocessor also runs at 10 MHz, compared with 5.33 MHz on the Model 339. Thus, floating-point intensive operations will execute significantly faster on the PS/2 machines. As might be expected, these AT descendants provide 16MB of memory address space (although neither supports that much memory using current memory expansion options), an eight-channel DMA (direct memory access) controller, 16-level interrupt system, system clock, realtime clock with CMOS RAM and battery backup, and audio subsystem with speaker.

Both models come standard with 1MB of memory installed on the system board, 384KB of which is configured as extended memory beginning at address 100000H (1MB). Like all other members of the PS/2 family, these machines feature the IBM enhanced keyboard—the same keyboard available with late-model ATs and XTs. The only difference is the connector cord, which uses a 6-pin miniature DIN connector on the PS/2 system unit end. An identical connector comes standard on the system board for the connection of an IBM mouse or other "pointing device." The two system-board connectors use the same voltages and signals. Key locks are provided on both machines, but they secure only the machine covers and do not disable the keyboards (as the key lock does on an AT). Keyboard security is provided via a password scheme (described below).

Each system board provides one parallel and one serial port. Each port uses standard 25-pin D-shell connectors; the connector for the parallel port is male, the connector for the serial port is female. Using the 25-pin connector instead of the less-common 9-pin connector found on the AT is a beneficial side effect of these connectors having been mounted on the system board rather than the bracket of an expansion board (as on the AT).

The new Video Graphics Array (VGA) subsystem is built into the system board of both machines. When used with the PS/2 family of analog color and monochrome displays, this subsystem supports several graphics modes (640 by 480 pixels in 2 and 16 colors, 320 by 200 pixels in 256 colors) and high-resolution text modes (720 by 400 pixels in monochrome and 16 colors), while maintaining compatibility with Color Graphics Adapter (CGA) and Enhanced Graphics Adapter (EGA) graphics and text modes. The VGA drives the video display through a 15-

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pin D-Shell connector mounted on the system board. The VGA automatically detects and drives any PS/2 display. Neither the connector nor the controller is compatible with the IBM Monochrome, Color, Enhanced Color, or Professional Graphics Displays available for the IBM PC family.

Perhaps most significantly, these machines feature the 16-bit architecture of IBM's Micro Channel. Designed to support multitasking operating systems, it is not compatible with the bus architecture used in the IBM PC family and the PS/2 Model 30. Micro Channel provides three types of connectors: 16-bit, 16-bit with auxiliary video extension, and 32-bit. Models 50 and 60 each use multiple 16-bit connectors (three on the 50 and seven on the 60) and one 16-bit slot with auxiliary video extension. The 32-bit connectors are available only on the Model 80. Micro Channel connectors are designed to require less force to insert adapter boards and to minimize current loop electromagnetic interference (EMI). They accept only expansion boards designed specifically to use the Micro Channel, as generally indicated by a suffix of /A in the board's name. Such boards differ physically and electrically from—and may not be interchanged with—PC or Model 30 adapter boards.

Hard disks are, of course, standard equipment in both machines: the Model 50 comes with a 20MB unit, the Model 60 with either a 44MB or 70MB unit. Like the Model 80, Models 50 and 60 each come with one 1.44MB 3.5-inch diskette drive and the option to add a second. These drives also can read and write diskettes in a 720KB mode that is compatible with the mode used by the drives on the Model 30, the IBM PC Convertible, and several other portable and desktop microcomputers. The controller for these drives is integrated onto the system board.

IBM's endeavor is made complete by a new exterior. Models 50 and 60 have a sleek look that the AT can only wish for. The single external likeness to the AT is the aforementioned keyboard—a modernized version of the original 84-key AT keyboard. Like the desktop and floor-standing versions of the IBM RT PC, PS/2 Models 50 and 60 are the same machine, dressed up for different occasions.

A SMALLER AT

With dimensions of 14.1 inches wide by 16.5 inches deep by 5.5 inches high and a weight of 21 pounds, the Model 50 system unit is smaller—and considerably lighter—than the AT, which measures 21.25 by 17.28 by 6.38 inches and weighs in at 43 pounds. Indeed, the 50 system unit looks rather narrow sitting behind its keyboard (see photo on page 110). The Model 50 also generates considerably less heat (494 BTU/hour versus 1,229 BTU/hour) and is noticeably quieter than the AT.

In a break from the past, IBM placed the power switch on the right front of the system unit—convenient, yet adequately recessed to prevent accidental operation. Nearby green and yellow LEDs (light emitting diodes) indicate power-on and hard-disk activity, respectively. The standard 1.44MB 3.5-inch diskette drive is located on the left front, with either a second 1.44MB drive or a matching cover plate to its right. The blue eject button on the drive is marked 1.44 to distinguish it from the Model 30's 720KB drive.

The key lock for the cover is located on the rear of the unit rather than the front (photo 1). The system power connector is located on the left rear; however, an auxiliary power outlet is not provided as it is with the AT. The keyboard, mouse, parallel interface, serial interface, and video display connectors are to the right of the power connector. Covers for the Model 50's three available Micro Channel expansion slots are located on the right rear of the system unit. These covers/end brackets are isolated from the adapter boards to which they are attached and the system ground, so that they act as a shield against electrical emissions. In keeping with one unfortunate IBM PC tradition, a system reset switch is not provided.

Removing the system unit cover is a simple matter of disengaging the key lock, loosening the two knurled-head screws on the top rear of the unit, pulling the cover forward slightly, then lifting it up. These screws and similar screws securing the Micro Channel expansion slot covers are slotted and can be loosened by hand or with a flat-blade screwdriver.

Inside, the Model 50 is somewhat like a split-level house, with the mass-storage devices on the upper level, the

PS/2 MODEL 50 AND MODEL 60 VITAL STATISTICS

Model 8550-021: $3,595
10-MHz Intel 80286 microprocessor
1MB system RAM
Realtime clock
Video Graphics Array
Parallel printer interface
Serial interface
Mouse interface
1.44MB, 3.5-inch diskette drive
20MB hard disk
101-key keyboard

Memory capacity
1MB expandable to 7MB using offered memory options

Expansion slots
16-bit Micro Channel: 4

Available slots
16-bit Micro Channel: 3

Options available
Any of the PS/2 monitors
.5MB/2MB Memory Board: $549
512KB Memory Expansion Kit: $165
2MB Expanded Memory Adapter/A: $1,045
10-MHz 80287: $525
Multi-Protocol Adapter/A: $295
Dual Async Adapter/A: $210
300/1200-bps Internal Modem/A: $395
PS/2 Mouse: $95
Second 1.44MB Diskette Drive: $245
5.25-inch External Diskette Drive: $335
5.25-inch External Diskette Drive Adapter/A: $60

Model 8560-041: $5,295
All standard features of Model 50, except that Model 8560-041 has a 44MB hard disk instead of a 20MB, four additional Micro Channel connectors, memory expandability to 15MB using memory options, and an additional 2KB CMOS RAM.

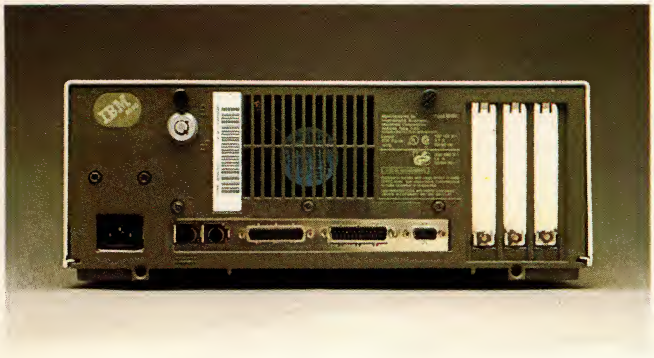
Model 8560-071: $6,295
All standard features of the 8560-041, except that Model 8560-071 has a 70MB hard disk instead of a 44MB.

Expansion slots
16-bit Micro Channel: 8

Available slots
16-bit Micro Channel: 7

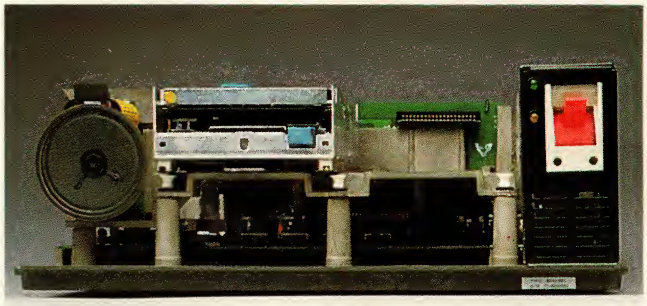
Options available
All options available with the Model 50, plus
44MB hard disk: $1,395
70MB hard disk: $2,395
115MB hard disk: $3,495

PHOTO 1: *Rear of Model 50 System Unit*



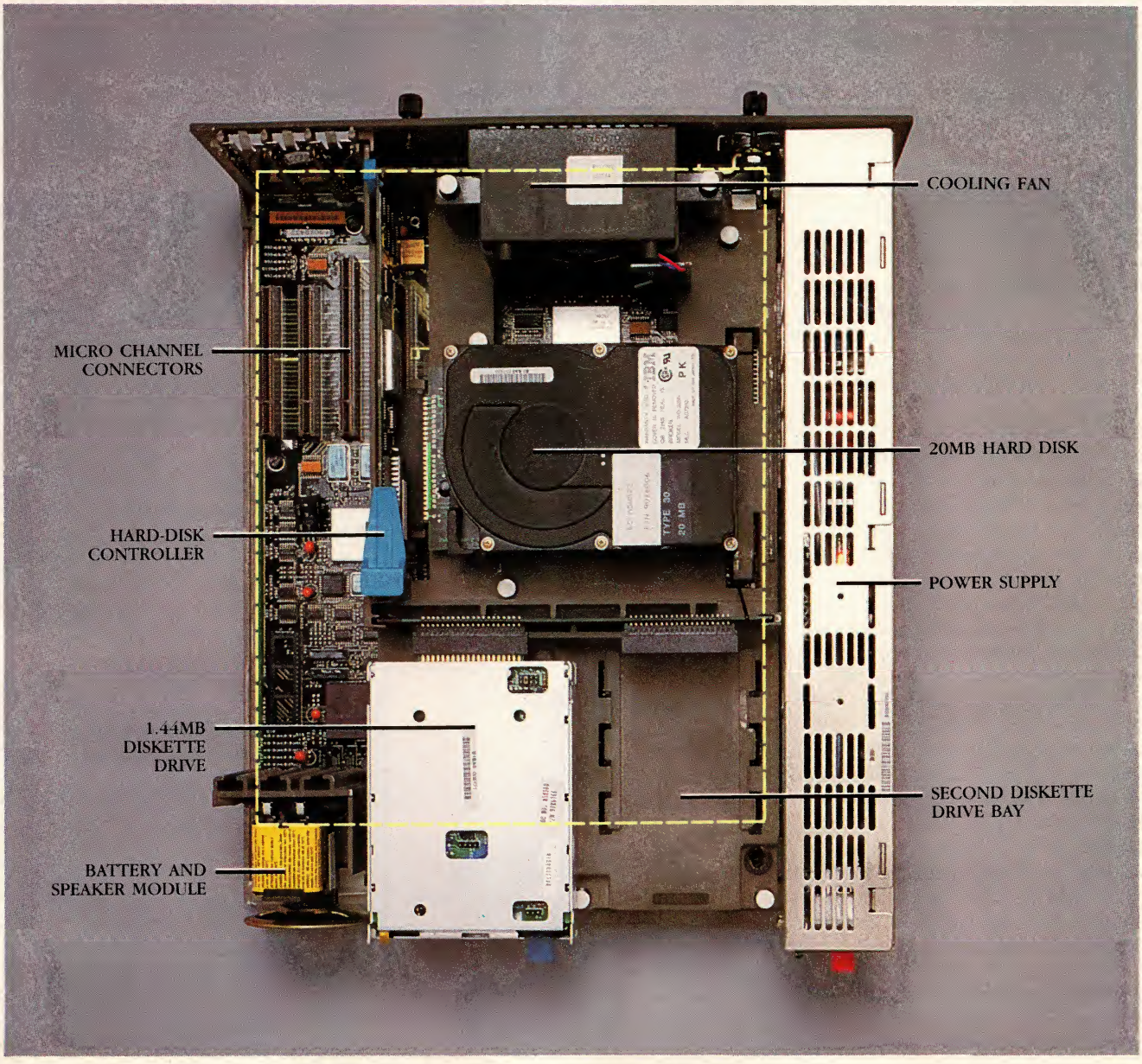
Connectors for the keyboard, mouse, parallel interface, serial interface, and video display are seen to the right of the power connector (it has no auxiliary outlet).

PHOTO 2: *Model 50 Front Minus Cover*



The Model 50's mass-storage devices sit at the right on the upper level, the system board on the lower level, and the Micro Channel adapters span the two on the left.

PHOTO 3: *Inside the Model 50 System Unit*



Perhaps the most interesting aspect of the interior is that all system components, from the power supply to the system board to the speaker/battery module connect without cables. The dotted outline indicates the location of the system board.

system board on the lower level, and the Micro Channel adapters spanning the two on the left side (see photos 2 and 3). In a marked departure from the construction of the AT, the system case, except for the top and sides of the removable cover, is made of a composite plastic material.

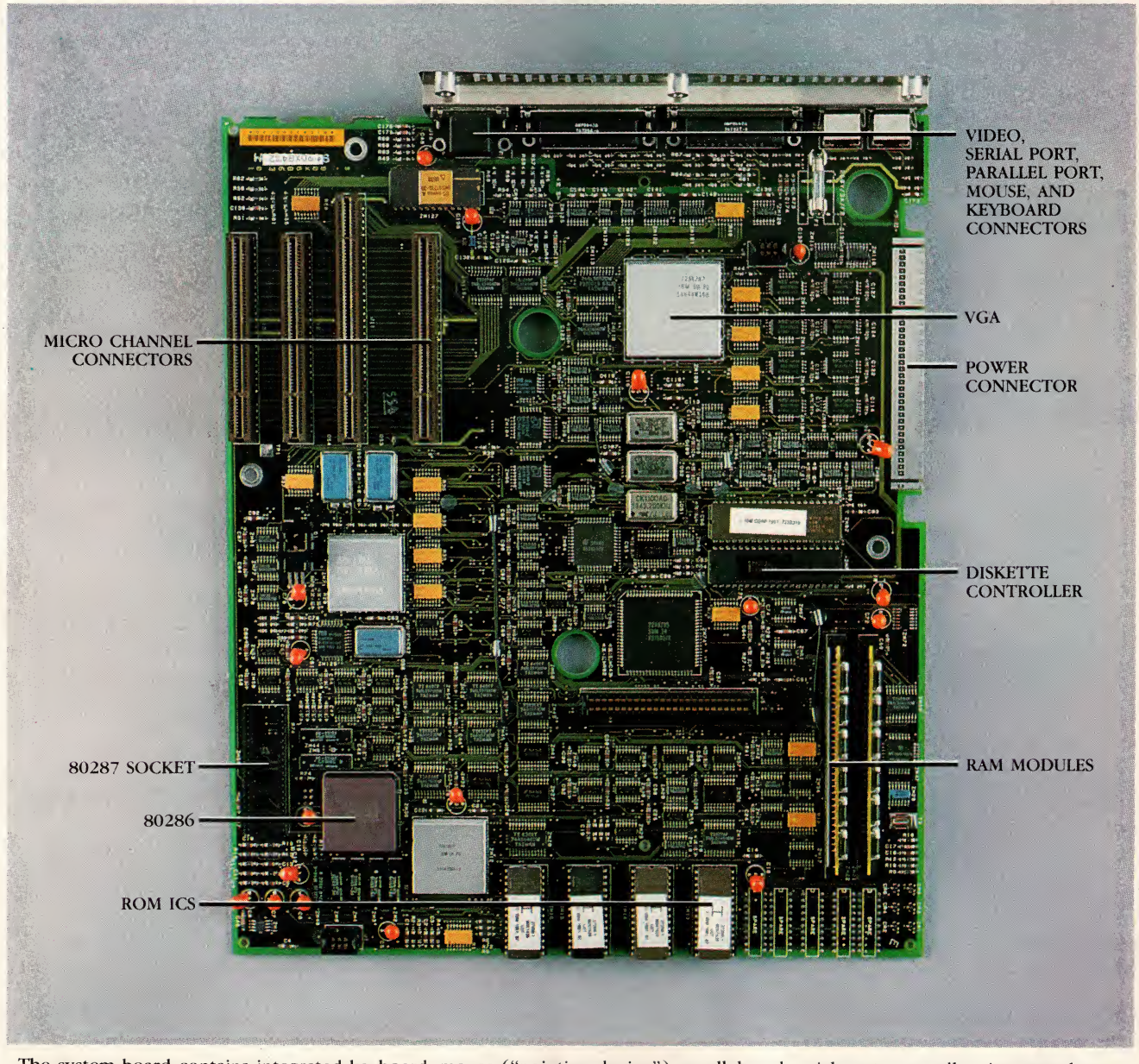
The speaker and battery assembly is mounted in the front of the unit to the left of the 1.44MB diskette drive. The open bay to the right of the diskette drive is available for another drive or the adapter assembly to connect the Model 4869 external 5.25-inch 360KB external diskette drive.

Perhaps the most interesting aspect of the interior of the Model 50 system unit is the absence of cables. All system components, from the power supply, to the system board (photo 4), to the speaker/battery module, connect without cables. The only screws are three (6-mm, slotted, hexagonal) that secure the power supply to the case and six that hold down the system board. The 94-watt power supply is a long, narrow element mounted on the right side of the unit. It can operate with two ranges of input power and automatically selects the appropriate range; the ranges are 90 to 137 and 180 to 265 volts, at any frequency between 47 and 63 Hz.

The cooling fan and 3.5-inch hard-disk drive are located to the left of the power supply. The disk drive connects directly to its controller, which is plugged into a dedicated Micro Channel slot in the system board. The blue plastic tabs on each end of the hard-disk adapter can be seen to the left of the disk drive at the rear and near the center of the system unit. These tabs make insertion and removal of Micro Channel boards easy on the fingers.

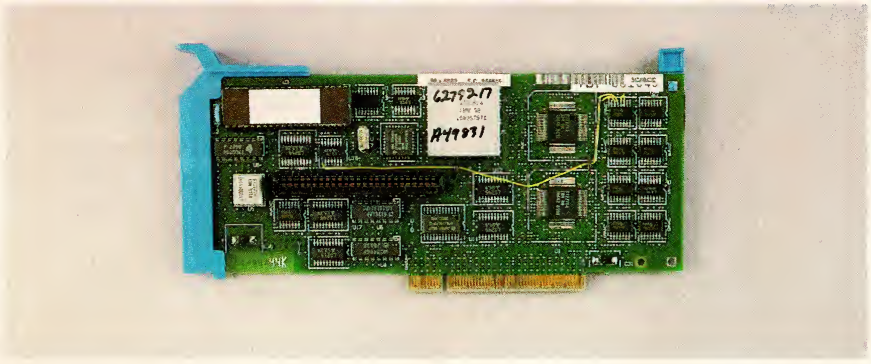
The Model 50's three available Micro Channel connectors are to the left of the hard-disk adapter. Micro Channel adapters are secured in the rear by a knurled-head screw on the outside of the system unit and in the front by a plastic card guide inside the system unit. The card guides are somewhat wider than Micro Channel boards

PHOTO 4: *Model 50 System Board*



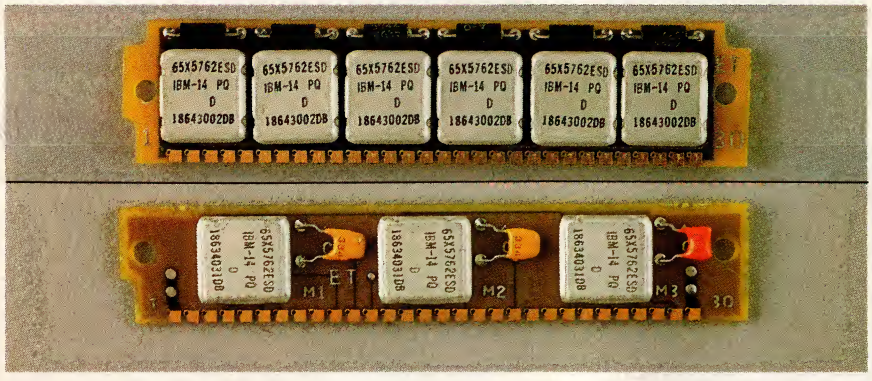
The system board contains integrated keyboard, mouse ("pointing device"), parallel, and serial ports, as well as integrated video display and diskette controllers. Surface-mounted components are used extensively, along with IBM custom VLSI chips.

PHOTO 5: *Model 50 Hard-disk Adapter*



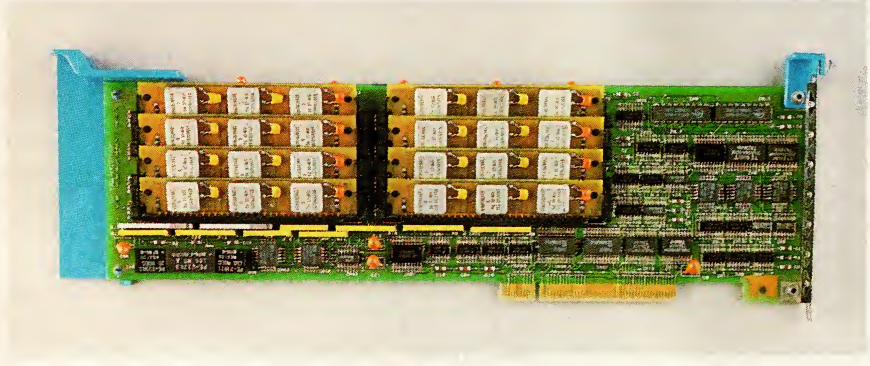
The hard-disk controller board features surface-mount technology, IBM VLSI circuitry, and one potted device that is covered with a ceramic shield.

PHOTO 6: *Models 50 and 60 SIMMs*



System board RAM on the Model 50 consists of two 512KB SIMMs (like the one shown at top); Model 60 system memory consists of four 256KB SIMMs (bottom).

PHOTO 7: *80286 Memory-expansion Board*



This board comes with a minimum 512KB of parity-checked RAM; it can hold a maximum 2MB. It is populated using 256KB SIMMs that are interchangeable with those used on the Model 60 system board (but different from those in photo 6).

to enable boards to be installed easier. The wide tabs on the front end of adapters provide for adequate spacing between adjacent boards; however, the leftmost board may wobble a bit.

The hard-disk adapter board features surface-mount technology, IBM VLSI circuitry, and one potted device covered with a ceramic shield (see photo 5). It does not have a metal mounting bracket as do other Micro Channel adapters; it is secured in the rear by a card guide built into the composite plastic subchassis.

Major components are held in place by built-in tabs and slots and white plastic pop-up connectors like the ones to the left of the power supply. The tool supplied for loosening the pop-up connectors is stored under the system speaker. Removing a diskette drive is a simple task of lifting a tab underneath its front and pulling the drive forward to disconnect it from the intermediary board that connects it to the system board. The hard disk is removed by depressing two plastic tabs to the right of the power supply and sliding the drive to the right to disconnect it from its controller.

At this point, full access to the system board can be had by removing the hard-disk controller and any other boards, then loosening the pop-up connectors that secure several system components. These include the system fan, the mass storage devices, the battery and speaker assembly, and the composite plastic subchassis that supports them. The system board can be extracted after three interior and three exterior screws are removed; this can be performed without removing the power supply because the system board does not extend under it. In keeping with the cableless interior of the system unit, the system board receives power directly from a connector built into the side of the power supply.

On the system board, the socket-mounted 80286 is neighbor to another socket for an 80287. The Model 50's 128KB of ROM is contained in four modules at front center. The connector for the diskette drives is located behind the ROM modules, and the integrated diskette controller is located to its right. The system RAM is located to the right of the diskette controller connector. It is composed of two single in-line memory modules (SIMMs), each of which provides 512KB of parity-checked memory (see photo 6). The RAM operates with one wait state, and memory refresh occurs every 15 microseconds. The SIMMs can be removed by carefully spreading their retaining brackets, then rotating the top of the SIMM away from the power supply.

The large metal-covered device near the back of the system unit is the VGA. Behind it are the system's video, serial, parallel, pointing device, and keyboard connectors; the pointing device and keyboard ports are fuse-protected. To the left center are the system's 14.3818-MHz, 32-MHz, and 40-MHz timing crystals. Behind the crystals are the system's four 16-bit Micro Channel connectors. The rightmost connector is reserved for the hard-disk controller, the next is a 16-bit slot with auxiliary video extension that permits access to the system video output port, and the other two are regular 16-bit Micro Channel connectors.



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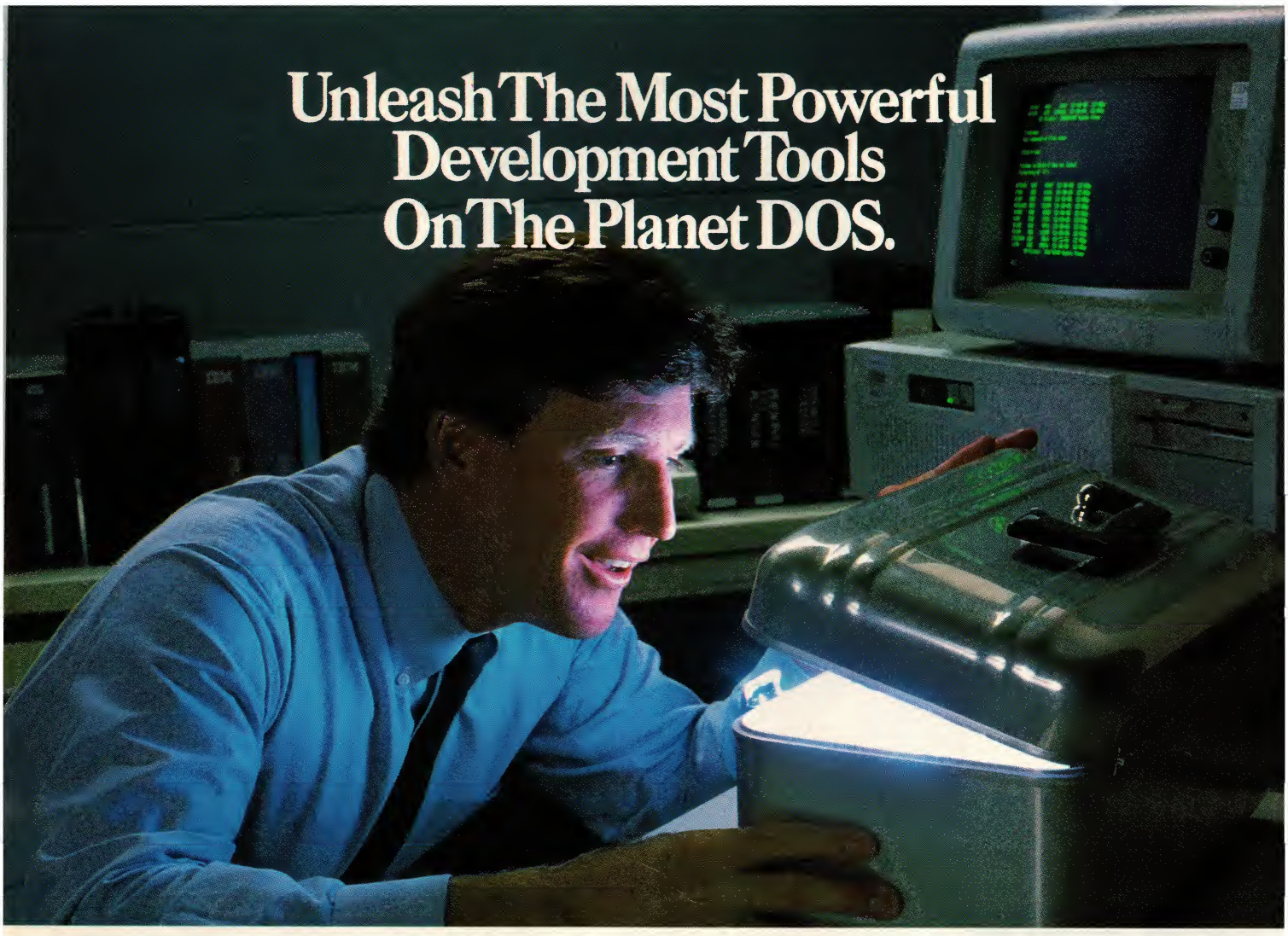
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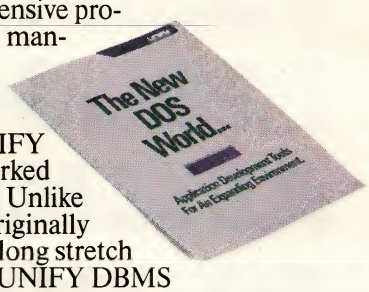
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The 80286 memory-expansion board can be installed in a Micro Channel slot to expand system RAM (see photo 7). This board comes with a minimum of 512KB of parity-checked RAM; when fully populated, it holds 2MB of RAM. The board uses 256KB SIMMs that are interchangeable with those used for system board memory on the Model 60—rather than the 512KB SIMMs used on the Model 50 system board (see photo 6). Because only three Micro Channel connectors are available on the Model 50, system RAM is limited to 7MB using IBM-supplied memory options.

A TALLER AT

The Model 60 system unit is larger than that of the AT. Its composite plastic case measures 23.5 inches high by 19 inches deep by 6.5 inches wide, compared to the AT's 21.25 by 17.28 by 6.38 inches. The system unit stands upright on the floor, fitting under a table or beside a desk, and is stabilized by two 12.5-inch metal feet that are rotated inward for shipment.

At 41.8 pounds, this system unit weighs almost as much as the AT, and it generates slightly more heat—1,240 BTU/hour compared to the AT's 1,229 BTU/hour. But the noise level it produces is the same as for the Model 50 (46 dB average when operating, 40dB average when idle, as recorded at a distance of 1 meter). Because it is a floor model, and therefore out of the way, it seems much quieter than an AT.

Another consequence of this floor placement is that the system unit no longer serves as a base for the system display. Users accustomed to the height of the AT display may find the Model 60's monitor too low and opt for height-adjustable stands that likely will be available soon.

The fold-down handle built into the top of the system case and the handholds built into its sides are most helpful in maneuvering the apparatus. Although the system unit is a bit heavy to be carried far by the handle, it can be pulled across a carpet easily: it is not the immovable object that the 92-pound, floor-standing RT PC is.

As on the Model 50, the power switch is prominent, with the same nearby LEDs indicating power-on and hard-disk activity. In keeping with the family, the unit's serial number is displayed on the front (below and to the right of the power switch) as well as on the back of the system case. This addition is particularly useful to organizations that deal with large amounts of equipment. The standard 1.44MB 3.5-inch diskette drive is located below the power switch, with either a second 1.44MB diskette drive or a matching cover immediately beneath it.

PHOTO 8: *Rear of Model 60*



The keyboard, mouse, parallel interface, serial interface, and video display connectors are mounted vertically beneath the power connector.

The system power connector is located on the top rear of the system unit (see photo 8). An auxiliary power outlet is not provided, as it is on the AT. The keyboard, mouse, parallel interface, serial interface, and video display connectors are mounted vertically beneath the power connector. Covers for the Model 60's eight Micro Channel expansion slots are located below the interface connectors.

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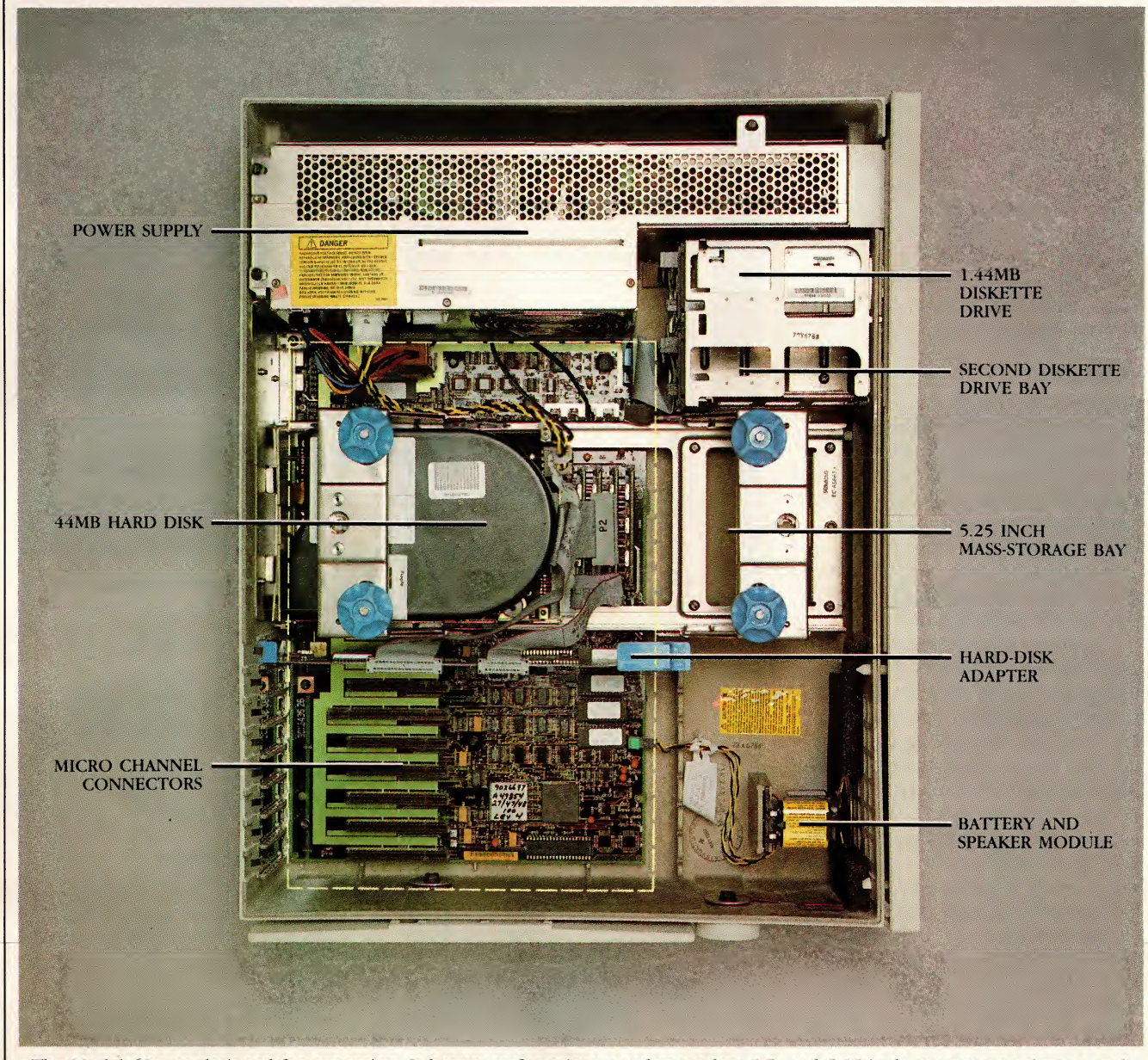
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PHOTO 9: *Inside the Model 60 System Unit*



The Model 60 was designed for expansion. It has space for primary and secondary 3.5- and 5.25-inch mass-storage devices and seven available Micro Channel connectors. The dotted outline indicates the location of the system board.

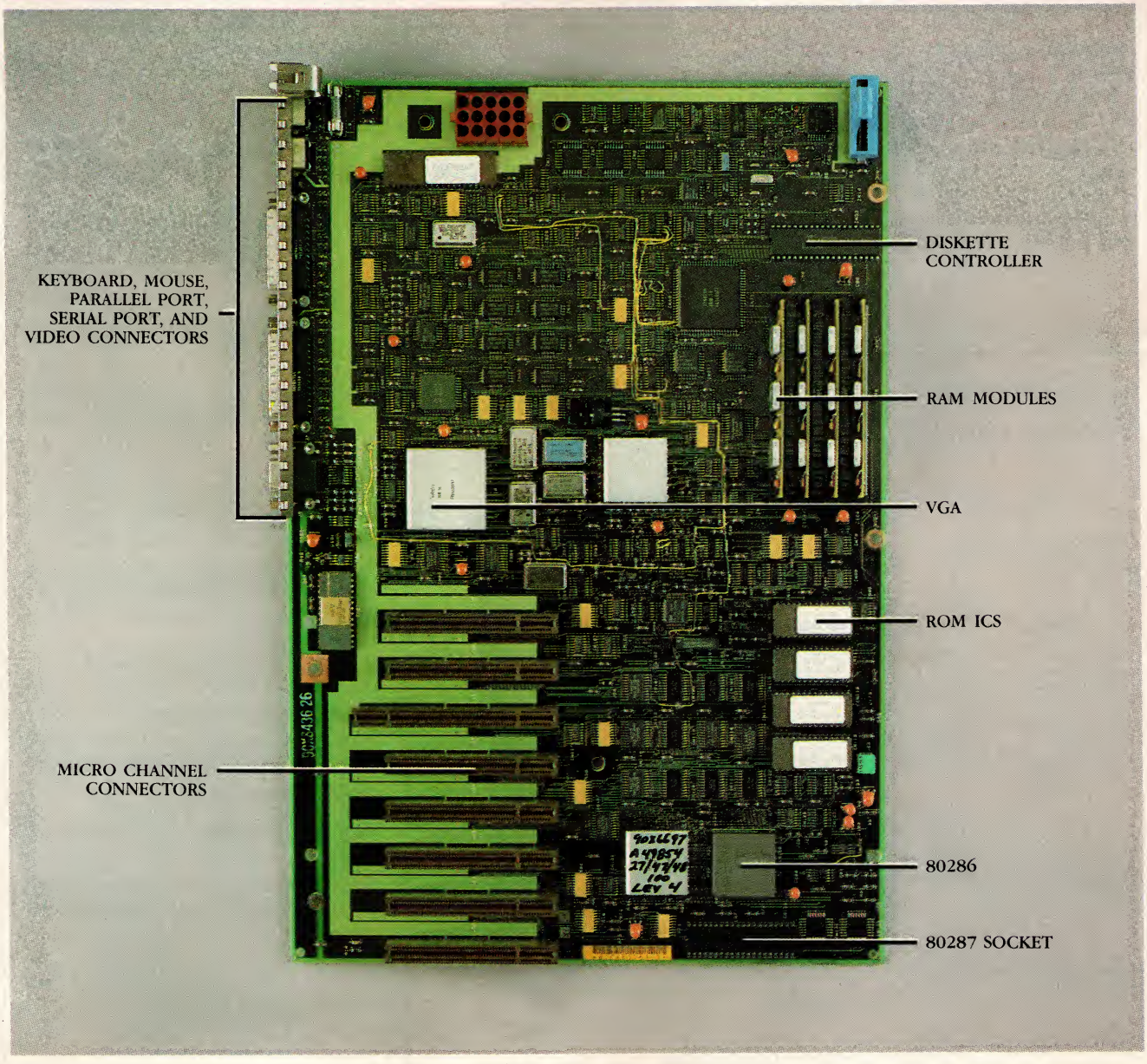
Access to the system unit is obtained by removing the left side cover. This is accomplished by unlocking the key lock at the top, loosening its two large slotted retaining screws, and lifting the cover out and up. As this is a floor-standing, rather than a desktop unit, the drudgery of moving the display is no longer a prerequisite to opening the system unit. In fact, if care is taken at installation to provide adequate clearance on the left side of the system unit, access for upgrades and maintenance is simple indeed.

One look inside the system unit reveals that the Model 60 was designed with expansion in mind (see photo 9). The 207-watt power supply is mounted at the top of the case, secured by three 6-mm, slotted, hexagonal-head screws. A plastic wire-tie is attached for use as a convenient handle when removing the power supply. The system cooling fan is located in the bottom of the power supply; the noise it generates is lessened by its blowing downward inside the system unit, rather than outward as on the AT. The power supply operates with either 110- or 220-volt AC, and automatically selects the appropriate input voltage range using the same criteria as the Model 50 power supply. A multiwire cable with a large 15-pin connector furnishes power to the system board. Two disk drive power connectors are mounted in the bottom of the power supply.

The system's standard diskette drive is mounted in a 3.5-inch drive bay below the power supply. This bay and the one immediately beneath it house connectors that are joined to the system board (photo 10) by a ribbon cable. These connectors, which provide both power and signals for the diskette drives, are compatible with the connectors used on the Model 50; thus, diskette drives may be exchanged easily between the two.

Drives are installed and removed in a procedure similar to that used on

PHOTO 10: *Model 60 System Board*

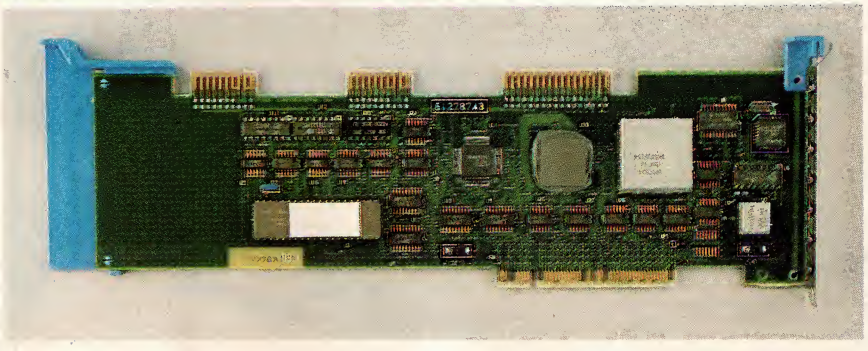


The Model 60 system board is functionally the same as the Model 50, but with some enhancements. The most obvious is its four additional Micro Channel connectors. This machine's system board RAM is made up of four 256KB SIMMs.

the Model 50. The Model 60 diskette bays are accessed by removing the system unit front cover, which must be pulled out and up from the bottom. It is also necessary to take off the side cover so that the plastic release tab on the rear of the drive bay can be pressed while simultaneously lifting the tab under the front of the diskette drive and pulling. As on the Model 50, either a second 1.44MB drive or the adapter assembly used to connect the Model 4869 external diskette drive may be installed in the open 3.5-inch bay.

Below the diskette drive bays is a frame for vertically mounting 5.25-inch mass-storage devices. Devices mounted

PHOTO 11: *Model 60 Hard-disk Adapter*



This adapter, which is provided standard on the Model 60 (8560-041), controls two 44MB hard-disk drives. The ESDI adapter that is provided standard on the Model 60 (8560-071), with a 70MB disk, also controls an IBM 115MB disk.

in this frame are secured by a metal mechanism that is adjusted by turning two large blue knobs. This mechanism tightens against a device's side-mounted rails to hold it securely. The reviewed PS/2 unit, a Model 8560-041, contained a 44MB hard disk manufactured by IBM. The Model 8560-071 comes standard with a 70MB hard disk. The 041 supports an additional 44MB drive, the 071 an additional 70MB or 115MB drive. The reviewed machine uses an ST506 disk controller, also manufactured by IBM (see photo 11). The 071 features an ESDI (enhanced small device interface) disk adapter, which comes standard on the Model 80.

The system speaker/battery assembly is located near the bottom front of the system unit, connected to the system board by a small twisted-wire cable. Between it and the system board are grooves molded into the system case to control (somewhat) the movement of any Micro Channel boards that are installed. As in the RT PC, the boards can wobble when the system cover is off. They are stabilized with the cover in place by a block of foam plastic material on the inside of the cover that presses against them.

Removing the system board requires, first, the removal of the 5.25-inch mass-storage device frame. This frame is secured to the system case by four 6-mm, slotted, hexagonal screws. These screws, like those securing the power supply and the system board, mate with metal fittings in the composite plastic case. Removing the system board is accomplished by withdrawing all Micro Channel boards, disconnecting the system board power connector and diskette drive connector, and removing seven more screws that secure the system board to the case and one that connects it to the system ground.

It is not necessary to remove the power supply in order to remove the system board because the system board does not extend beneath it. Once the system board is removed, a metal plate that makes contact with the power supply and various grounding pads on the system board are visible. This plate is installed to extend the system board grounding plane.

The Model 60 system board is functionally identical to the Model 50, but enhanced. The most obvious addition is that the Model 60 board (which is slightly bigger than the AT's) has seven available Micro Channel connectors compared with the Model 50's three. (Because the hard-disk controller on each model requires one connector, the number of available connectors is one less than the total number of connectors on each system board.)

The Model 60 contains 2KB of CMOS RAM in addition to the 64 bytes of nonvolatile RAM contained on the Motorola MC146818A realtime clock/CMOS RAM chip used on both it and the Model 50. This RAM extension is reserved for storage of system information and diagnostic use. The system battery that maintains information in the RT/CMOS device also maintains the information in the 2KB RAM extension. The system's socket-mounted 10-MHz 80286 is located on the lower right of the system board, with the socket for a 10-MHz 80287 just below it.

The system board RAM is located above the ROM. It is made up of four SIMMs, each of which provides 256KB of parity-checked memory (see photo 6); the RAM operates with one wait state. The SIMMs can be removed by carefully spreading their retaining brackets, then rotating the top of the SIMM toward the front of the system board. Because these memory modules

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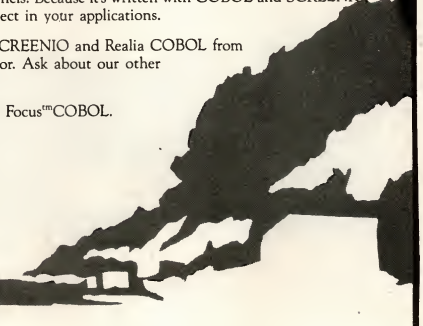
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are packaged the same as the 512KB modules on the Model 50, it seems reasonable that IBM might offer a Model 60 with 2MB of system memory when more software capable of using extended memory becomes available.

Additional memory can be added to the Model 60 via 80286 memory-expansion boards, which are also available for the Model 50. These boards use SIMMs that are interchangeable with those on the system board; expansion boards may contain between 512KB and 2MB of memory. Using this option to the fullest, the Model 60, with its seven available Micro Channel connectors, may contain 15MB of RAM.

The integrated diskette controller and the blue connector that joins it to the diskette drive bays is located above the system RAM. The system's three timing crystals are situated near the center of the system board. To their left is the VGA, and to the left of the VGA are the system's video, serial, parallel, pointing device, and keyboard connectors (the last two are fuse-protected, as on the Model 50).

TABLE 1: *System Board I/O Address Map*

HEXADECIMAL ADDRESSES	DEVICE
0000–001F	DMA controller
0020, 0021	Interrupt controller 1, 8259A
0040, 0042, 0043, 0044, 0047	System timers
0060	Keyboard auxiliary device
0061	System control port B
0064	Keyboard, auxiliary device
0070, 0071	RT/CMOS and NMI mask
0074, 0075, 0076	Reserved
0081, 0082, 0083, 0087	DMA page registers (0–3)
0089, 008A, 008B, 008F	DMA page registers (4–7)
0090	Central arbitration control port
0091	Card selected feedback
0092	System control port A
0093	Reserved
0094	System board set-up
0096, 0097	POS, channel connector select
00A0–00A1	Interrupt controller 2, 8259A
00C0–00DF	DMA controller
00F0–00FF	Math coprocessor
0100–0107	Programmable option select
0278–027B	Parallel port 3
02F8–02FF	Serial port 2 (RS-232)
0378–037B	Parallel port 2
03BC–03BF	Parallel port 1
03B4, 03B5, 03BA, 03C0–03C5	Video subsystem
03CE, 03CF, 03D4, 03D5, 03DA	Video subsystem
03C6–03C9	Video DAC
03F0–03F7	Diskette drive controller
03F8–03FF	Serial port 1 (RS-232)

IBM is now using previously reserved portions of the I/O address map to support new features introduced with the PS/2 family, such as the Video Graphics Array.

A CUT ABOVE

Features added to the Model 50 and Model 60 over and above those of the AT make them better single-task performers and more capable multitasking or networked machines. (All features mentioned apply to both models unless otherwise specified.)

The Micro Channel architecture and VGA provide several new and enhanced features. To support these features, IBM is now using previously reserved parts of the I/O address map. Table 1 lists the I/O addresses used by system board devices.

Serial ports now operate at 19.2 Kbps. A special watchdog timer is available, in addition to the 1.19-MHz system timer and tone-generation timer that are provided on the AT. This watchdog timer can detect error conditions in which the system timer interrupts are being ignored.

Two levels of BIOS are provided. The compatibility BIOS (CBIOS) supports many current applications and 1MB of memory address space. An additional advanced BIOS (ABIOS), which will provide support for IBM's Operating System/2 (OS/2) and other multitasking operating systems, supports a 16MB address space. ROM BIOS is assigned to the top of the first and last 1MB of the 16MB address space (0E0000H and FE0000H). Each member of the PC and PS/2 families has a model identification byte at location F000:FFFEH of system ROM. The system identification for each member of the PS/2 and PC family is shown in table 2. This information should be accessed using interrupt 15H, with AH = C0H, which also returns a submodel byte and BIOS revision level, if present.

PS/2 computers support an extended BIOS data area in addition to the 256-byte BIOS data area at 400H to 4FFH. The power-on self test (POST) allocates memory for this area as needed, starting at 640KB and working downward in 1KB increments. The first byte in the extended BIOS data area is initialized to the length in kilobytes of this area. The reviewed systems allocated 1KB of memory for this data area. The area's use is currently undocumented for Models 50 and 60; the Model 30 *Technical Reference* specifies that it supports the pointing device.

Three kinds of password protection are available on Models 50 and 60: power-on, server mode, and keyboard. Power-on password protection enables users to set a password that must be entered whenever the computer is turned on. When the power comes on, a small key appears on the screen indicating that the user has three tries to enter a correct password, otherwise the machine must be turned off and on again. Once a correct password is entered, the computer boots-up.

The power-on password is set by starting the system from the IBM Reference Diskette and choosing Set Features from the main menu, then Set Passwords. When the password is entered, it is stored in the machine's battery-backed CMOS memory. If users forget their passwords, they can clear the memory by removing the battery for at least 20 minutes (of course, unauthorized users could do this too unless the system cover is locked).

Network server mode is a variation on the power-on password that is intended for computers used as network servers. This mode also is selected from the menu on the Reference Diskette. When server mode is in effect, the system can be restarted from the hard

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CIRCLE NO. 148 ON READER SERVICE CARD

TABLE 2: *System Identification*

PRODUCT	BIOS DATE	MODEL BYTE	SUBMODEL BYTE	REVISION
PC	04/24/81	FF	—	—
PC	10/19/81	FF	—	—
PC	10/27/82	FF	—	—
PC/XT	11/08/82	FE	—	—
PC/XT	01/10/86	FB	00	01
PC/XT	05/09/86	FB	00	02
PC*jr*	06/01/83	FD	—	—
PC/AT	01/10/84	FC	—	—
PC/AT	06/10/85	FC	00	01
PC/AT	11/15/85	FC	01	00
PC/XT Model 286	04/21/86	FC	02	00
PC Convertible	09/13/85	F9	00	00
PS/2 Model 30	09/02/86	FA	00	00
PS/2 Model 50	—[a]	FC	04	00
PS/2 Model 60	—[a]	FC	05	00
PS/2 Model 80	—[a]	F8	00	00

[a]*BIOS date not available.*

Each PC and PS/2 has a model byte located at F000:FFFEH. In some cases, a submodel byte and BIOS revision-level byte are required to identify the module.

disk without entering the power-on password, but the keyboard remains locked until the correct password is entered. (No prompt is given for the power-on password when the system is restarted from the hard disk.) This permits server and other remote systems to restart automatically after a power failure even though the keyboard is locked—an improvement over the AT, which will not allow the system to be reinitialized if the key lock is locked.

The keyboard password enables a user to lock the keyboard without turning off the system. The KP program, which is supplied on the Reference Diskette, is used to set the keyboard password; this keyboard password can be different from the power-on password. Once the password has been selected, typing KP locks the keyboard and typing the password unlocks it.

PS/2 Models 50, 60, and 80 support 32 types of hard-disk drive, as they are listed in table 3. The Model 30 supports drive types 0 through 26. The original AT (BIOS dated 1/10/84) supports only types 0 through 14, and ATs with a BIOS dated 6/10/85 or later support types 0 through 23.

Also, an external 360KB 5.25-inch diskette drive can be added to the Model 50 or 60 instead of the second 1.44MB drive. The 360KB drive requires one Micro Channel expansion slot; in addition, it will neither read nor write 1.2MB diskettes, which makes data migration and exchange between PS/2 machines and the AT a problem.

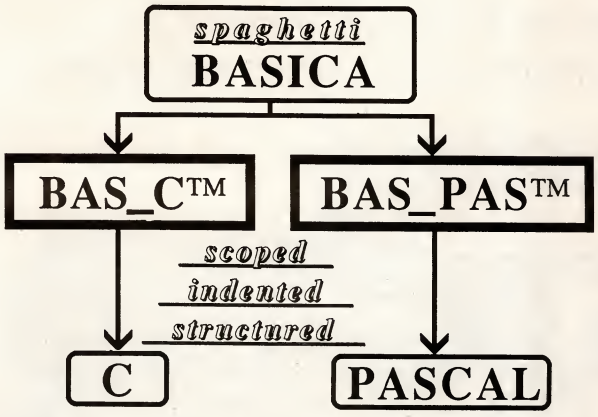
Data can, on the other hand, be transferred directly from a member of the PC family to any member of the PS/2 line by way of the parallel port using a cable connector and software supplied with the IBM Data Migration Facility. This is, however, a one-way street: PCs cannot receive data from a PS/2 using this facility because they do not have bidirectional parallel ports as the PS/2 computers do. IBM markets a 720KB 3.5-inch external diskette drive for the PC, XT, and AT, and an equivalent internal model for the AT and some XTs. But this solution is less than ideal, because older-model machines often have a much shorter lifespan than data on older-format media.

The unavailability of internal 5.25-inch diskette drive support (or even 1.2MB external support) on the Model 60 seems particularly shortsighted. If the machine is to be used as a shared resource, it will require the capability to read and write all diskette types (including 1.2MB) that are supported by the PC and AT. Furthermore, the Model 60 has a mounting frame that is designed for the installation of additional 5.25-inch mass-storage devices, a connector on the power supply to power them, and a removable panel in its front cover that would allow the installation of two half-height diskette drives. This entire situation will be an ongoing inconvenience for installations that include ATs until viable solutions become available from either IBM or other companies.

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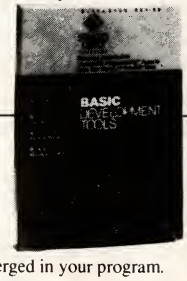
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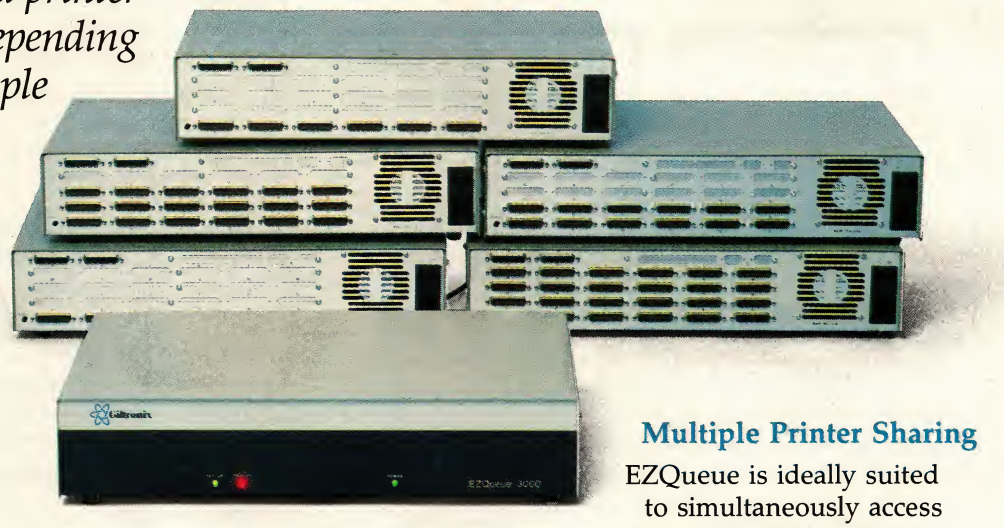
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TABLE 3: *Disk Drives Supported*

DRIVE TYPE	NUMBER OF CYLINDERS	NUMBER OF HEADS	LANDING ZONE CYLINDER	PRECOMPENSATION CYLINDER	DEFECT MAP
0(0H)	No hard disk installed				No
1(1H)	306	4	305	128	No
2(2H)	615	4	615	300	No
3(3H)	615	6	615	300	No
4(4H)	940	8	940	512	No
5(5H)	940	6	940	512	No
6(6H)	615	4	615	0FFFFH (none)	No
7(7H)	462	8	511	256	No
8(8H)	733	5	733	0FFFFH (none)	No
9(9H)	900	15	901	0FFFFH (none)	No
10(AH)	820	3	820	0FFFFH (none)	No
11(BH)	855	5	855	0FFFFH (none)	No
12(CH)	855	7	855	0FFFFH (none)	No
13(DH)	306	8	319	128	No
14(EH)	733	7	733	0FFFFH (none)	No
15(FH)	Reserved				
16(10H)	612	4	663	0 (all cylinders)	No
17(11H)	977	5	977	300	No
18(12H)	977	7	977	0FFFFH (none)	No
19(13H)	1,024	7	1,023	512	No
20(14H)	733	5	732	300	No
21(15H)	733	7	732	300	No
22(16H)	733	5	733	300	No
23(17H)	306	4	336	0 (all cylinders)	No
24(18H)	612	4	663	305	No
25(19H)	306	4	340	0FFFFH (none)	No
26(1AH)	612	4	670	0FFFFH (none)	No
27(1BH)	698	7	732	300	Yes
28(1CH)	976	5	977	488	Yes
29(1DH)	306	4	340	0 (all cylinders)	No
30(1EH)	611	4	663	306	Yes
31(1FH)	732	7	732	300	Yes
32(20H)	1,023	5	1,023	FFFFH (none)	Yes

Types 33(21H) through 255(FF) are reserved.

PS/2 Models 50, 60, and 80 support these 32 types of hard-disk drives. The Model 30 supports only types 0 through 26.

FAMILY SOFTWARE

IBM DOS 3.3 is available for Models 50 and 60 at extra cost. This new version of DOS, replacing 3.2, can be used on both the PC and PS/2 family. Version 3.3 contains several enhancements in addition to providing support for new features offered by the PS/2 computers; and it includes the BASIC interpreter, version 3.3. This product is described in the BASIC 3.2 reference manual, also available at extra cost. Cassette BASIC is provided in ROM for compatibility purposes; it is loaded if the system is booted with drive C: not configured as a system disk, and with no system diskette in drive A:.

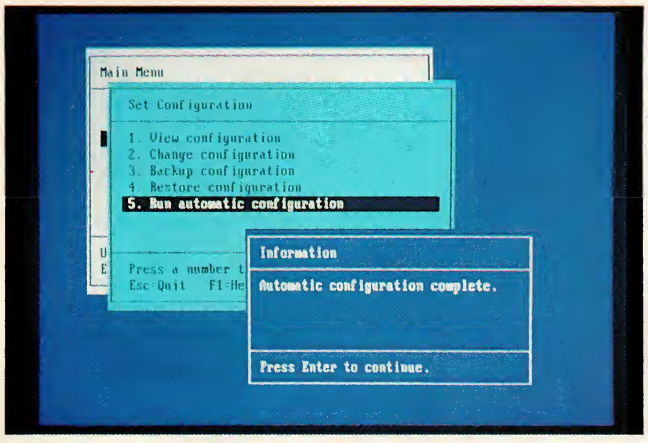
IBM provides a hard-disk cache program with Models 50, 60, and 80. This program uses a set of sector buffers to improve disk read performance. The sector buffers may be located in either base or extended memory. The cache program runs in base memory; it is a device driver (IBMCACHE.SYS) that is provided as a hidden file on the Model 50/60 Reference Diskette. Its companion installation program IBMCACHE.COM is used to copy the driver to the hard disk and to create or modify CONFIG.SYS to allow its use.

Models 50 and 60, as well as the Model 80 (and the AT and XT/286) will be able to run OS/2; the 8086-based Model 30, however, will not. This new operating system will be offered in two editions: Standard and Extended. The Standard Edition will support large memory, multiple concurrent applications, graphics and windowing, and an environment compatible with DOS 3.3. It will be capable of running multiple applications simultaneously with one non-time-critical DOS 3.3 application. The OS/2 applications will be able to run continuously even when in background mode, but the DOS application will run only when it has control of the display and keyboard.

The Standard Edition is to be released in two phases. Version 1.0, scheduled to appear in the first quarter of 1988, will provide all features just mentioned, except graphics and windowing. These capabilities are currently planned to be incorporated into version 1.1; however, the planned release date of 1.1 will not be announced until the fourth quarter of 1987.

Minimum recommended memory for running OS/2 Standard Edition version 1.0 are 1.5MB when configured to run only OS/2 applications, and 2MB

PHOTO 12: *Configuration and Set-up Menus*



System configuration can be accomplished using the "Run automatic configuration mode" option, which uses the ID number of each installed Micro Channel adapter and information on the Reference Diskette to configure the system.

PHOTO 13: *Advanced Diagnostics Menu*



Although not documented in the *Quick Reference*, the Reference Diskette contains an advanced diagnostic program that is invoked by pressing Ctrl-A from the Reference Diskette main menu. (Documentation is provided elsewhere.)

when configured to run both DOS 3.3 and OS/2 applications. OS/2 version 1.0 requires 5MB of hard-disk space for system files, plus additional hard-disk space for swap and history files.

The Extended Edition of OS/2 will include a relational database manager and a communications manager in addition to all the capabilities of OS/2 Standard Edition 1.1. The database manager will be consistent with the IBM host family of relational database products—Database 2 (DB2), Structured Query Language/Data System (SQL/DS), and Query Management Facility (QMF). The communications manager will support communications between personal computers and host networks using a variety of methods and protocols including SDLC, distributed function terminal (DFT) mode to a 3X74 cluster controller, Token-Ring Network, IBM PC Network, and asynchronous links. IBM will announce the *planned* availability of the first release of the Extended Edition (1.1) in the fourth quarter of 1987.

The minimum recommended memory for running the Extended Edition when configured to run only OS/2 applications is 3MB. Additional memory will be required depending upon the applications mix. IBM advises users who anticipate large databases, large numbers of programs or files, or the execution of several concurrent applications to be sure that their computer's mass storage can be expanded beyond 20MB. Users with such needs likely will not be able to use the Model 50 with its 20MB hard-disk capacity limitation.

IBM also has announced new compilers that support both DOS 3.3 and OS/2. These products, which are scheduled for release in the first quarter of 1988, include COBOL/2, FORTRAN/2, C/2, Macro Assembler/2, Pascal Compiler/2, and BASIC Compiler/2 (plus the BASIC Interpreter reference manual version 3.3). COBOL/2 will be released in two stages. An early version called COBOL 2.0, which supports both DOS 3.3 and OS/2, is available now; it will be upgraded to COBOL/2, when it becomes available, at no additional cost.

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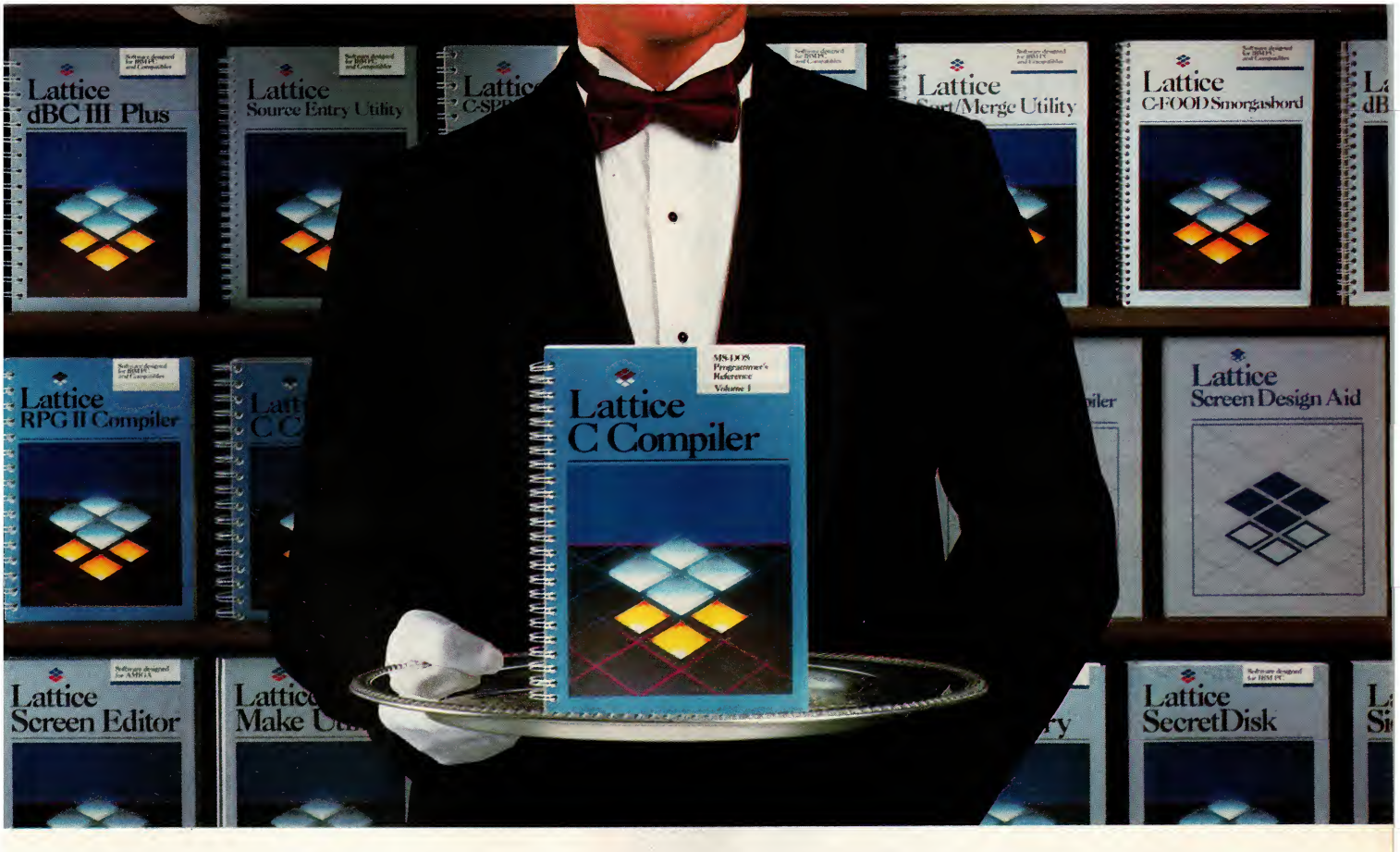
Thanks to convenience introduced by the Micro Channel architecture, and the many functions and capabilities built into the system board, Models 50 and 60 are much easier to set up and install than an AT. A set-up sheet explains how to unpack and set up the computer. This consists of little more than some simple connections: the system power cord, the keyboard cord, the display to the system unit, and the two power cords to an electrical outlet.

The *Quick Reference* also gives straightforward, well-illustrated directions on system set-up and option installation. Initial installation consists of booting the system using the Reference Diskette, and setting the system configuration and the date and time, via menu (see photo 12). System configuration is accomplished using the "Run automatic configuration mode" option, which reads the ID number of each installed Micro Channel adapter and uses information in adapter description files (ADFs) on the Reference Diskette to configure the system.

The reference tools do a fine job of showing the user how the system works, but he is left somewhat on his own when things go wrong (except for the advice, "Have the system unit serviced"). For example, if a user installs or removes a Micro Channel adapter, at power-up the system displays a numeric code (or two) and waits for user intervention (unless the reference or a system diskette is in drive A:, in which case it will initialize the system from the diskette). Veteran AT users then will likely press F1 (even though no **RESUME = F1 KEY . . .** message is displayed), expecting the system to go ahead and boot from the hard disk.

In an effort to protect the integrity of the hard disk, the system will beep and refuse to do so, because it knows the system configuration has changed, but has not been updated in CMOS memory. Pressing F1 once again results in a graphic display prompting the user to insert a diskette and press F1. Having done so with the Reference Diskette, the system can be initialized, configured, and restored to normal operation. It would be helpful, particularly for new users, if such exceptional, but nonetheless important possibilities, were explained in the *Quick Reference*, and if the display prompting the user to insert a diskette and press F1 came up immediately rather than after two depressions of F1.

On the other hand, IBM provides a most useful advanced diagnostics program on the Reference Diskette (although it is not documented in the *Quick Reference*). This program is invoked by pressing Ctrl-A from the Reference Diskette main menu. These diagnostics will hardware-format a hard disk and provide the selective diagnos-



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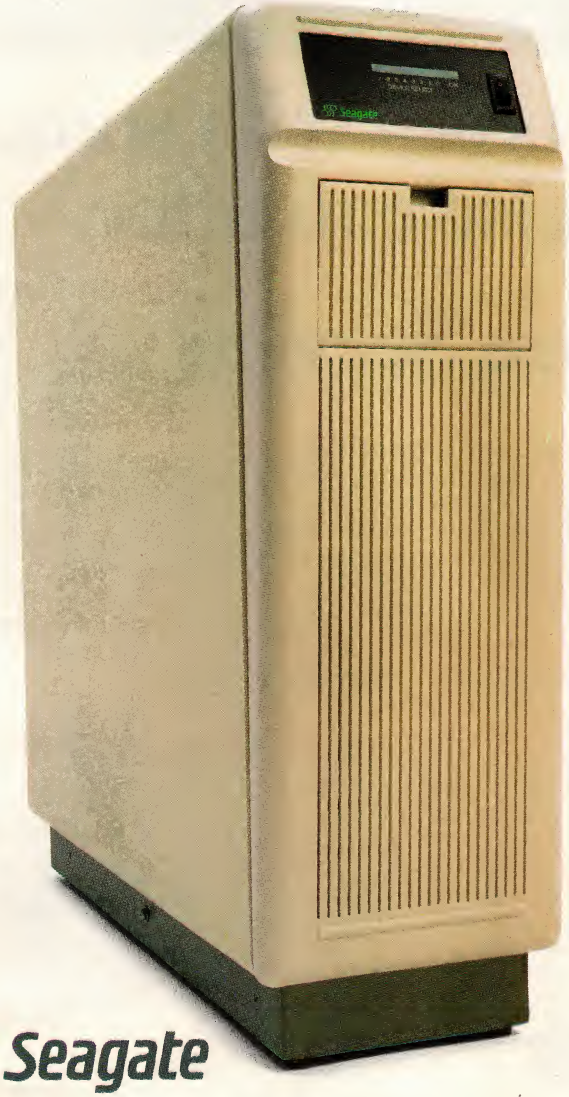
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tic services provided by the PC family advanced diagnostics. Photo 13 shows the advanced diagnostics menu.

Documentation for the advanced diagnostics is provided in the *Hardware Maintenance Service* manual, available separately. Other manuals so offered include individual technical reference manuals for system devices and adapters, the *Model 50/60 Technical Reference*, and the *Personal System/2 and Personal Computer BIOS Interface Technical Reference*.

The *Model 50/60 Technical Reference* provides substantial in-depth information about the two systems. The level of detail varies by chapter, but new features such as the Micro Channel architecture and the VGA are described at length. It is a more organized description of the system than the *AT Technical Reference*, which seems to be a collection of information not provided elsewhere. The 50/60 reference does not, however, provide schematics as the AT reference does.

The *BIOS Interface Technical Reference* includes BIOS information for all IBM PC and PS/2 computers. This is a lot of material, requiring a fair number of footnotes and explanations to differentiate among services provided on various models. Although BIOS listings are not provided (as they have been in past technical references for each computer), the functional operation of the BIOS is described in detail in a fairly organized manner.

IBM provides a one-year, limited warranty on both the Model 50 and the Model 60. Customer carry-in is required for warranty repairs; on-site warranty repair is available as an option. The company gives indication that it expects these machines to be reliable and easy to repair by its low, on-site maintenance fees: the minimum cost for the Model 50 is $180, and for the Model 60-041 and 071, $190 and $210 respectively. This is substantially lower than the $546 minimum maintenance charge announced with the 30MB PC/AT Model 339.

OFF AND RUNNING

The Model 50 and Model 60 were evaluated under *PC Tech Journal*'s two-phase procedure for testing PC/AT-compatible machines. First, the PS/2 computers were tested with commonly used hardware and software. The Micro Channel architecture prevented the 50 and 60 from testing with the add-in boards normally used. Therefore, the machines were analyzed with the usual attachable peripheral devices, plus sev-

eral Micro Channel boards that perform many of the same functions as the AT-compatible boards. Both machines were then tested using the *PC Tech Journal* compatibility and performance tests and the results were compared with those of an 8-MHz AT. (For an explanation of these tests, see "Out from the Shadow of IBM . . . ," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52 and "Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 70.)

Models 50 and 60 worked with all hardware tested without incident. The products installed and tested include a 10-MHz 80287, an IBM 80286 memory expansion option with 2MB of memory, an IBM Token-Ring Network Adapter/A, Hayes 1200 and 2400 Smartmodems, an IBM mouse and a Microsoft mouse, an IBM Model 8503 monochrome display, IBM Model 8512 and 8513 color displays, and an IBM ProPrinter.

Review software included Borland's SideKick 1.56A, SuperKey 1.15A, Living Videotext's Ready! 1.00D, and Turbo Lightning 1.01A. These programs tested the systems' behavior with terminate-and-stay-resident (TSR) packages. DCA/Crosstalk Communications' Crosstalk XVI 3.61 and Hayes' Smartcomm II were used with the Hayes modems to check communications capabilities. DOS 3.3's VDISK and IBMCACHE measured extended memory mode operations. Microsoft Windows and Word were run to test graphics capabilities and mouse support.

All TSR programs ran as advertised. (Ready! was run using only conventional memory because a Model 50/60 expanded memory board was not available.) However, some problems were encountered with Microsoft Word 3.1. When used in graphics mode with the Microsoft serial mouse, Word permitted the use of only one color combination. When used in text mode with no mouse or the Microsoft serial mouse, the display lost synchronization. When used with the IBM mouse, everything seemed to work fine. A newer version, Word 3.11 (released in April 1987), worked with a mouse, without a mouse, and in text mode, as well as graphics mode. Crosstalk XVI version 3.61 and Smartcomm II version 2.2 worked without incident with the Hayes Smartmodem 1200 and 2400.

The *PC Tech Journal* compatibility and performance suite is made up of five programs. ATBIOS examines the BIOS and BIOS data areas. ATKEY tests AT keyboard compatibility. ATPERF

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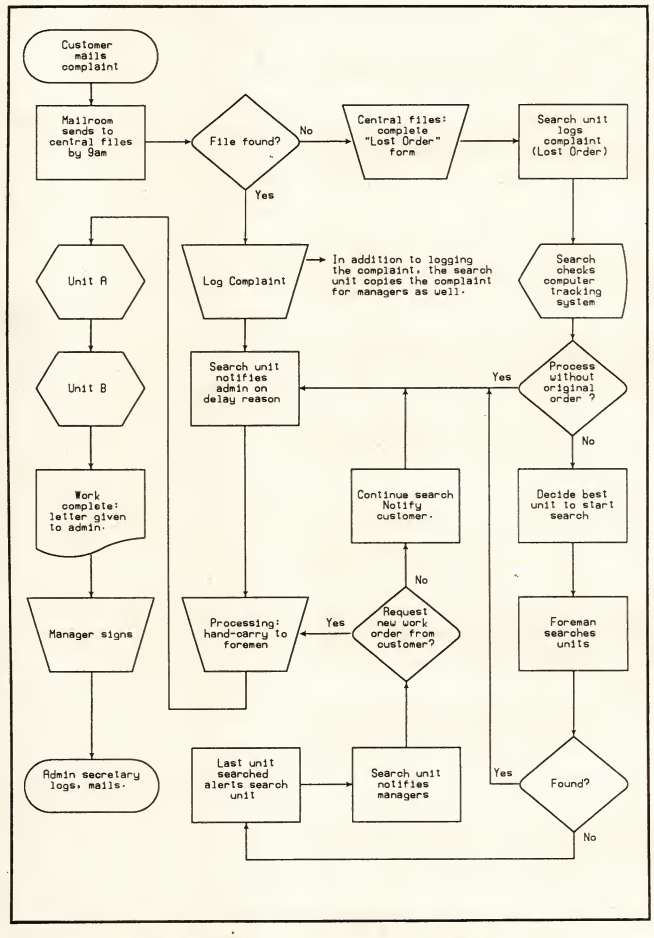
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TABLE 4: *Compatibility and Performance Tests*

	8-MHz AT, 30MB DISK[a]	MODEL 50 (8550-021)	MODEL 60 (8560-041)
ATBIOS			
ROM BIOS date	11/15/85	02/13/87	02/13/87
ATPERF			
Average RAM instruction fetch (μs)			
BYTE	.250	.20 (125)[b]	.20 (125)
WORD	.403	.32 (125)	.32 (125)
Average RAM read time (μs)			
BYTE	.401	.33 (120)	.33 (120)
WORD	.401	.33 (120)	.33 (120)
Average RAM write time (μs)			
BYTE	.401	.31 (130)	.31 (130)
WORD	.401	.31 (130)	.31 (130)
Average ROM read time (μs)			
BYTE	.401	.33 (120)	.33 (120)
WORD	.401	.33 (120)	.33 (120)
Average CGA video write time (μs)			
BYTE	1.208	1.68 (72)[c]	1.65 (69)
WORD	2.415	3.34 (72)	3.49 (69)
CPU clock rate (MHz)	8.0	10.0 (125)	10.0 (125)
Math coprocessor clock rate (MHz)	5.3	10.0 (187)	10.0 (187)
Refresh overhead (%)	7.1	7.6	7.3
RAM read wait states	1	1	1
RAM write wait states	1	1	1
ROM read wait states	1	1	1
Video write wait states (CGA)	8	14	14
ATFLOAT			
Performance as percentage relative to AT	100	180	180
ATDISK			
Sectors/track	17	17	17
Heads	5	4	7
Cylinders	731	609	730
Total space (million bytes)	31.81	21.20	44.48
Track-track seek time (ms)	6.0	16.7	6.0
Average seek time (ms)	37.1	81.1	36.1
Effective transfer rate (KB/sec)[d]	170.1	255.0	255.0
DOS file I/O (sec) (with/without cache)	7.3	10.3/11.6	7.1/8.7
Interleave	3	1	1

[a] *The figures for the IBM PC/AT are the average results from several machines, whereas the results for Models 50 and 60 were taken only from the review sample model.*
[b] *Figures shown in parentheses represent the relative performance expressed as a percentage compared to* PC Tech Journal's *baseline machine, the 8-MHz, 30MB AT.*
[c] *Model 50 and Model 60 measurements were taken using the VGA in CGA mode.*
[d] *This rate is measured by reading an entire track repeatedly. On disks with 1:1 interleave, an extra disk revolution must take place before the start of the track can be read again, thus cutting the absolute transfer rate (510KB/sec) in half.*

Models 50 and 60 performed as expected. They turn in an overall better performance than the AT—except for the Model 50's slow hard disk.

measures CPU and 80287 clock rates, as well as memory access times. ATFLOAT measures typical floating-point operations with the 80287 installed. Finally, ATDISK evaluates hard-disk performance. Table 4 shows the test results.

ATBIOS indicates a standard use of the ROM BIOS data area by the PS/2 line; it displays an IBM copyright and a date of 02/13/87 for each. ATKEY verified keyboard compatibility. The following performance data are the same for both machines unless noted.

The next test, ATPERF, indicated that these machines perform instruction fetch and RAM and ROM access about 1.25 times faster than an 8-MHz AT. Using the integrated VGA in CGA mode, video write performance is 25-percent slower than that obtained using a CGA in the AT. The 80287 clock rate was measured at 10-MHz, as expected.

ATFLOAT measures the time taken to perform 100 multiplies on a 20-by-20 matrix and compares that to the time required to perform the same operation on an 8-MHz AT. Although floating-point operations take up the majority of the time required for this operation, the CPU time necessary to loop through the matrices is included as well. Models 50 and 60 perform ATFLOAT 1.8 times faster that the standard AT, which reflects the speed ratio of the PS/2 10-MHz 80287 to that of the AT's 5.33-MHz coprocessor.

ATDISK was run with the IBM disk cache installed with default parameters and without the cache installed. Use of the cache improved the DOS disk I/O results by better than 10 percent (10.3 seconds versus 11.6) on the Model 50 and nearly 20 percent on the Model 60 (7.1 seconds versus 8.7). More significant, however, is the difference in performance between the hard disks of these two PS/2 machines.

In a word, the Model 50's hard disk is slow. Its average track-track seek time of 16.7 ms (milliseconds) and average seek time of 81.1 ms is XT-class, not AT. Although this is offset by IBMCACHE under certain circumstances, by and large, this is not a machine for disk-intensive use. The Model 60's 44MB disk, on the other hand, turns in quite respectable numbers: 6.0 ms for track-track seek and 36.1 ms for seek time. It is much better suited to server or other disk-intensive applications, particularly when configured with the available 70MB hard disk.

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IBM customers buy IBM equipment, therefore they will buy these machines. And, price aside, why not? For users, these computers are easier to set up, install, move, and operate. For IBM and its dealers and service organizations, the PS/2 line is easier to manufacture, upgrade, and service. The Model 50 and Model 60 improve on the AT in almost every way. Moreover, by offering two models instead of one, IBM enables the user to purchase only the performance and capacity he requires.

Granted, much of that capacity and performance will be required to support OS/2. But it remains to be seen just how many users will decide that the cost and effort required for OS/2 will be worth its promised benefits, and whether PS/2 machines will somehow run OS/2 faster or more reliably than ATs or AT compatibles.

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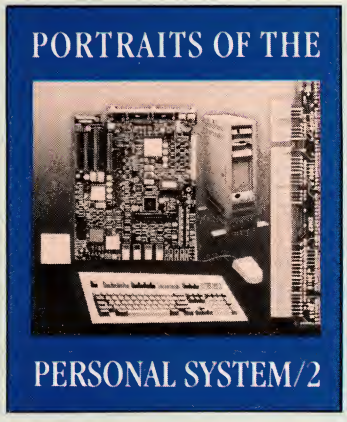
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Model 80: Performance and Potential

STEVEN ARMBRUST and
CAROLINE HALLIDAY

With the 80386-based PS/2 Model 80, IBM sends a message to other manufacturers of high-performance personal computers that it will not give up this evolving market without a stiff fight.

The Personal System/2 Model 80 is, at its introduction, IBM's top-of-the-line machine for personal computing. IBM did more with this big brother to Models 50 and 60 than simply add an 80386 to a PC/AT. The Model 80's 32-bit implementation of the new Micro Channel bus architecture sets it apart. Offering a good performance now—it can run current software—the Model 80 stands poised for future operating systems that will take full advantage of the 80386 microprocessor and the 32-bit bus.

The Model 80 is the logical extension to the 80286-based Models 50 and 60. It embodies the same design philosophy, one that delivers improved reliability, higher performance, and greater functionality than the PC family, yet maintains compatibility with that family wherever possible. A good choice now for CPU-intensive operations that really need an 80386 and 80387 math coprocessor, such as CADD (computer-aided design/drafting), the Model 80 carries tremendous potential, especially for multitasking.

This floor-standing system comes in two versions, one with a 16-MHz 80386, the other a 20-MHz 80386. When this article was written, only the 16-MHz version was available. The unit examined was a Model 80 (8580-071), which had a 70MB hard disk and 2MB of 80-nanosecond (ns) RAM. (As the Model 80 was scheduled for a July 1987 release, this unit had to be examined quickly on-site at an IBM facility to be included in this review. This precluded *PC Tech Journal*'s standard, in-depth look at the machine.) The 16-MHz Model 80 is also available with a 44MB hard disk (8580-041); a 20-MHz Model 80 equipped with a 115MB hard disk (8580-111) is scheduled to be available in the fourth quarter of 1987.

The tested unit also had a second 70MB hard disk and IBM's 8512 color display, as well as the integral mouse, serial, and parallel ports, a 1.44MB 3.5-inch diskette drive, and the standard AT-enhanced keyboard. The Video Graphics Array (VGA) subsystem is standard to all PS/2 family members (although the Model 30 offers only a subset). A sidebar listing Model 80 Vital Statistics accompanies this article.

Physically, the Model 80 is similar to the Model 60 inside and out (except for the 80's 32-bit slots and its 16-MHz CPU crystal speed). Its dimensions are

similar—23.5 inches high by 6.5 inches wide by 19 inches deep; and, at 45.3 pounds (with one hard disk installed), it is only slightly heavier. Thus, its sturdy handle (which folds flat on the top of the system unit) is helpful for pulling the unit, but it cannot be carried easily by one person. Of course, the same can be said about the AT.

One reason the unit is not as heavy as it looks is that the case is made entirely of composite plastic material. The AT is housed in metal, which IBM chose in the early going to limit electromagnetic interference (EMI). The PC/XT case is made of nickel-plated copper. However, the advanced design of the Micro Channel bus and the redesigned expansion slot covers reduce EMI sufficiently to permit IBM to go lighter (and less expensive) on the case. The silver-colored plastic coating, which appears to have been sprayed onto the inside walls, is fairly resilient. (Note, however, that this model does contain a small metal screening plate behind the system board, as does the Model 60.)

Like the Model 60, the Model 80's legs swivel to allow easy shipment. But IBM recommends in its documentation that the cover be removed to turn the legs, which brings up an interesting question. One strong selling point for these machines to the typical business user is that no *internal* switches need to be set. With this problem of going inside the machine solved, why create another such situation?

The diskette drives and front-panel lettering are oriented to the system unit's vertical placement, which seems ideal under a table or desk. Such a configuration provides easy access to the drives and power switch, without consuming an entire desktop in the process. The power switch is located on the front, where it can be reached easily no matter where the unit is mounted or what other equipment is placed near it. But IBM still has not added a button to reset the system without stressing the hard-disk drives by removing power to them.

A power indicator light and hard-disk access light also are present on the front panel; the key lock, however, is out of the way on the left side. The key lock physically locks the left side panel of the system unit (which *is* the cover), but does not lock the keyboard as it does on an AT. However, a password is available to lock the keyboard. The locked cover on the unit does reduce the chances of the battery being removed from the unit (which erases the stored password). The function of the password and keyboard lock system is the same as on the Model 60.

The Model 80 comes standard with one 1.44MB, 3.5-inch diskette drive mounted horizontally in the top portion of the system unit directly beneath the power switch (see photo 1); it has room for another 3.5-inch peripheral immediately beneath the first. The supplied diskette drive will read and write both 1.44MB and 720KB diskettes. When the drive is in 720KB mode, it provides a method of transferring information to and from an AT with an optional 3.5-inch diskette drive. It would, however, have been sensible for IBM to offer a 1.44MB disk drive for the AT to allow a more effective transfer of data. (For more information on the problems inherent to establishing a common media between machines and data migration to the PS/2 family, see the "What IBM did Right and Wrong, Part/2," Will Fastie, p. 46.)

The diskette controller is integrated onto the Model 80 system board (photo 2). On the tested machine, a 5.25-inch hard disk is mounted vertically, immediately beneath the 3.5-inch drive bay and to the rear of the unit. A second hard disk can be mounted in front of the first (and was for testing). The drive types supported are the same as on the Model 60 (see table 3 in "Models 50 and 60: New-Generation ATs," Jim Shields, p. 110). The hard-disk controller, located in the first expansion slot, can support two hard disks. However, it is not possible to have an ESDI (enhanced small device interface) and an ST506 disk controller in the same machine at the same time.

The power connector for the Model 80 is located at the top of the rear panel (see photo 3). On this machine, no spare outlet is available as on the AT, so the monitor power cable must be connected separately and the monitor must be turned off independently of the system unit.

The Model 80 comes standard with an asynchronous communication (serial) port and a parallel printer port, which now are located on the system board. The parallel printer port uses the standard female 25-pin connector, just like those used throughout IBM's PC line. However, the port circuitry provides an extended mode not available with earlier IBM parallel ports. This extended mode provides bidirectional data-transfer capabilities that IBM's PS/2 Data Migration Facility uses to transfer data via a parallel cable between systems with 3.5-inch drives and those with 5.25-inch drives. In addition, it provides users with a simple I/O in-



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terface for laboratory equipment without necessitating the design of a board. (For more information on the extended use of the parallel port, see "An Architecture Redefined," David Methvin, p. 58, on the new Micro Channel.)

In place of the 9-pin serial connector found in the AT, the Model 80 uses the 25-pin, male serial-port connector like those found in most PCs and XTs. IBM says that it has not abandoned the 9-pin format, but that it will use it only when space limitations force the smaller size (such as on option cards with multiple ports). The connectors are located on the rear panel of the system unit, along with the keyboard and mouse connectors (see photo 3).

Consistent with IBM's new switchless philosophy, the system board has no switches to specify port numbers or to disable ports. Instead, the Model 80 includes software to perform these operations (on the Reference Diskette supplied with the machine). This information is stored in battery-backed RAM that is in addition to the RAM needed to support the realtime clock. This realtime clock is included on the system board and performs identically to its counterpart on the AT.

The Model 80 BIOS is the same as that described for Models 50 and 60. It has two sections: the CBIOS provides compatibility with the PC, XT, and AT; the ABIOS is the advanced BIOS that will provide additional functions, such as multitasking, to future operating systems. In addition, the watchdog timer on the system board can be set to time-out after a specified number of system clock ticks. The default setting for this timer is off so that compatibility with the PC line is maintained. This timer could be a valuable debugging tool for developing applications (see "An Architecture Redefined").

In photo 3, the two round connectors immediately above the serial and parallel ports are the keyboard and auxiliary-device connectors. These two connectors look exactly alike but cannot be used interchangeably for the IBM mouse (or "pointing device") and keyboard, as is possible on the Model 30. These connectors are different from the keyboard connector used in the AT, so AT-enhanced keyboards cannot be used on the Model 80 unless a new cable with the appropriate connector is used. This ability to replace the keyboard could be useful for troubleshooting or for replacing the feel of the IBM keyboard with another type.

Even though the keyboard and mouse connectors are situated on the back of the unit, IBM uses well-designed cables, with one flat edge on the connector. The flat edge enables the user to orient the connector by touch. The keyboard itself has the same key layout and feel as the IBM 101-key enhanced keyboard used in the latest ATs and XTs (see "Keying on a Standard," Bob Smith, July 1987, p. 134). The cable is extra long so that the system unit can be positioned on the side of a desk or table without the threat of running out of keyboard cable.

Beneath the serial port is the small video connector, which routes the output to a monitor from IBM's VGA, the standard video controller that supports monochrome, Color Graphics Adapter (CGA), and Enhanced Graphics Adapter (EGA) modes, by emulation, as well as providing extensions. The VGA provides modes of 640 by 480 pixels with 2 and 16 colors, 320 by 200 with 256 colors, and 720 by 400 in monochrome and text. As discussed in "VGA: Evolutionary Half-step" (John D. Cockerham, p. 74), the new video system uses analog monitors. Instead of providing the digital red-green-blue signals that IBM CGA and EGA adapters provide (which then were converted to analog values by the monitors themselves), the VGA presents analog signals directly to the monitor. The existing IBM displays (Monochrome, Color, Enhanced Color, and Professional Graphics) will not work with the VGA.

The monitor included with the test unit was IBM's 8512 Color Display. It produced crisp text and colors as good as those found on most EGA-type monitors. The monitor has an optional tilt-and-swivel stand, enabling it to be adjusted to the optimal viewing angle.

PS/2 MODEL 80 VITAL STATISTICS

Model 80-041: $6,995
16-MHz Intel 80386 microprocessor
1MB system RAM
Realtime clock
Video Graphics Array
Parallel printer interface
Serial interface
Mouse interface
1.44MB, 3.5-inch diskette drive
44MB hard disk
101-key keyboard

Model 80-071: $8,495
All standard features of Model 80-041, except that Model 80-071 has 2MB of system RAM and a 70MB hard disk in place of the 44MB disk.

Model 80-111: $10,995
All standard features of Model 80-071, except that Model 80-111 has a 20-MHz 80386 and a 115MB hard disk.

Memory capacity on system board
2MB on Models 80-041 and 80-071
4MB on Model 80-111

32-bit memory capacity of system
16MB with IBM expansion options, the limit supported by OS/2

Expansion slots
32-bit Micro Channel: 3
16-bit Micro Channel: 5

Available slots
32-bit Micro Channel: 3
16-bit Micro Channel: 4

Options available
Any of the PS/2 monitors
8514/A adds palette of 256,000 colors with 256 on-screen: $1,290
80387 Math Coprocessor: $795
Memory expansion kits: $695
PS/2 Mouse: $95
44MB hard disk: $1,395
70MB hard disk: $2,395
115MB hard disk: $3,495
5.25-inch External Diskette Drive: $335
3.5-inch Internal Diskette Drive: $245
300/1200-bps internal modem: $395

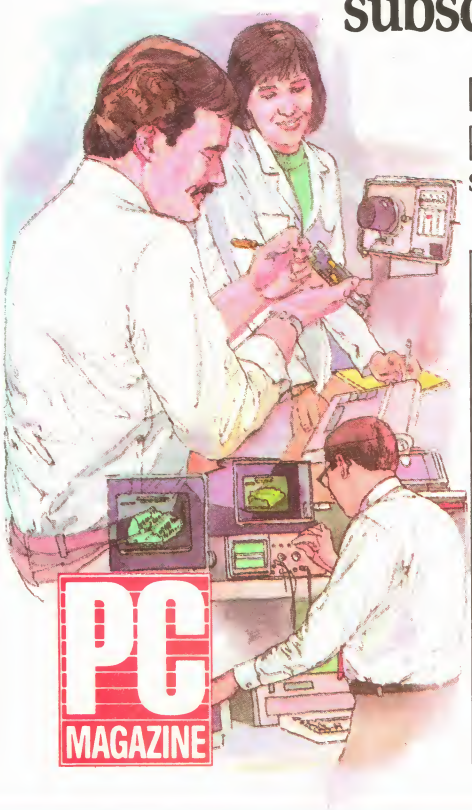
EXTRA-CURRICULAR

The PS/2 family brings many new features to the IBM audience. Foremost among these is the Micro Channel architecture, a new bus that offers many opportunities for high-performance options, but is incompatible with the PC's expansion bus.

The Model 80 implements the full 32-bit capability of the Micro Channel architecture, giving the unit's 80386 32-bit data and address paths to expansion cards. The 32-bit slots also provide eight lines for IBM's Matched Memory protocol as an extension to the Micro Channel connector. This protocol is designed to enable the bus to handle future processors and memory components that operate faster than the bus' default cycle time operation. These boards can be 16- or 32-bit cards, but 8-bit cards cannot use the Matched Memory Cycles (MMCs).

The RAM and ROM in this machine are better performers as well. In con-

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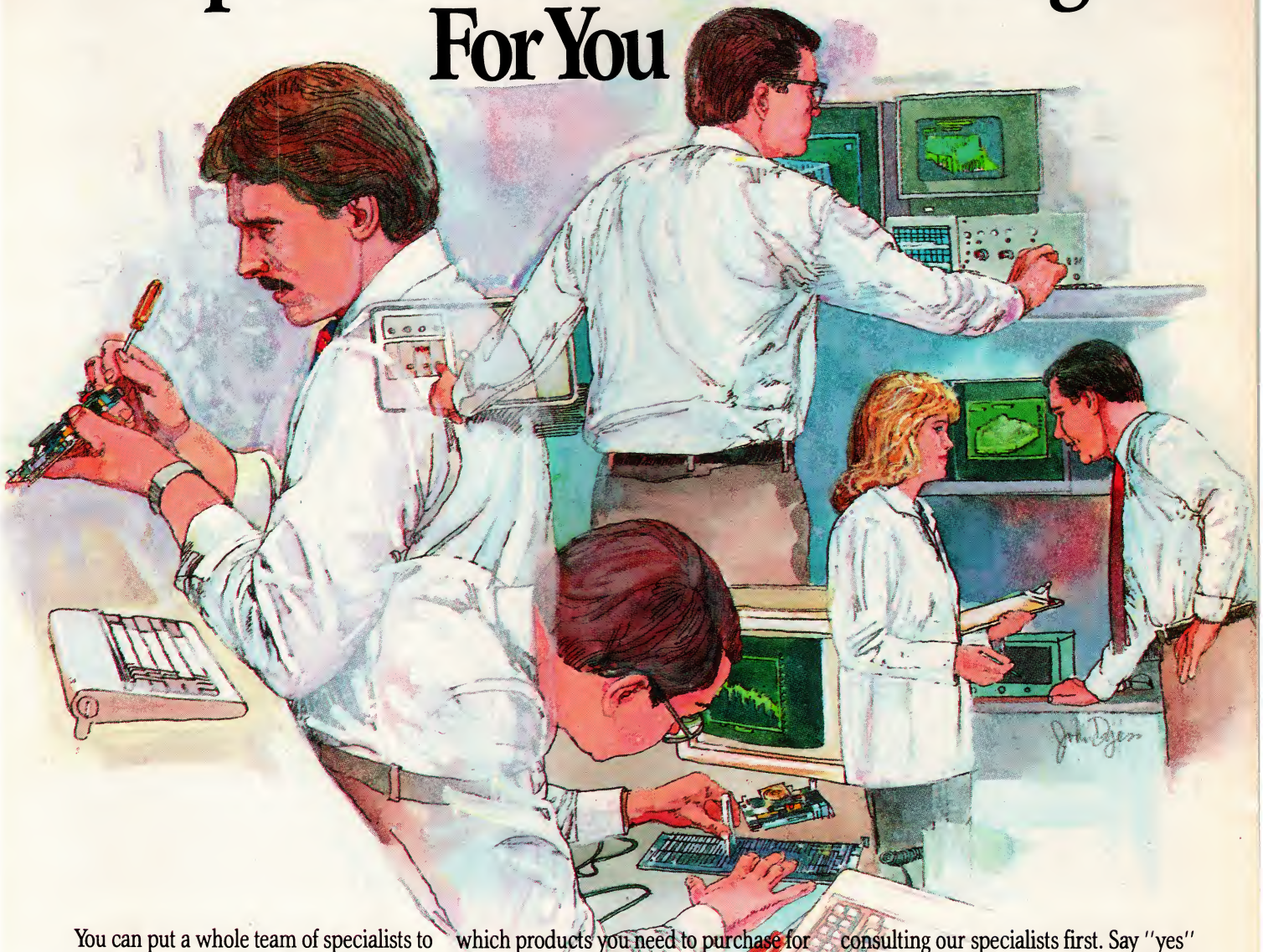
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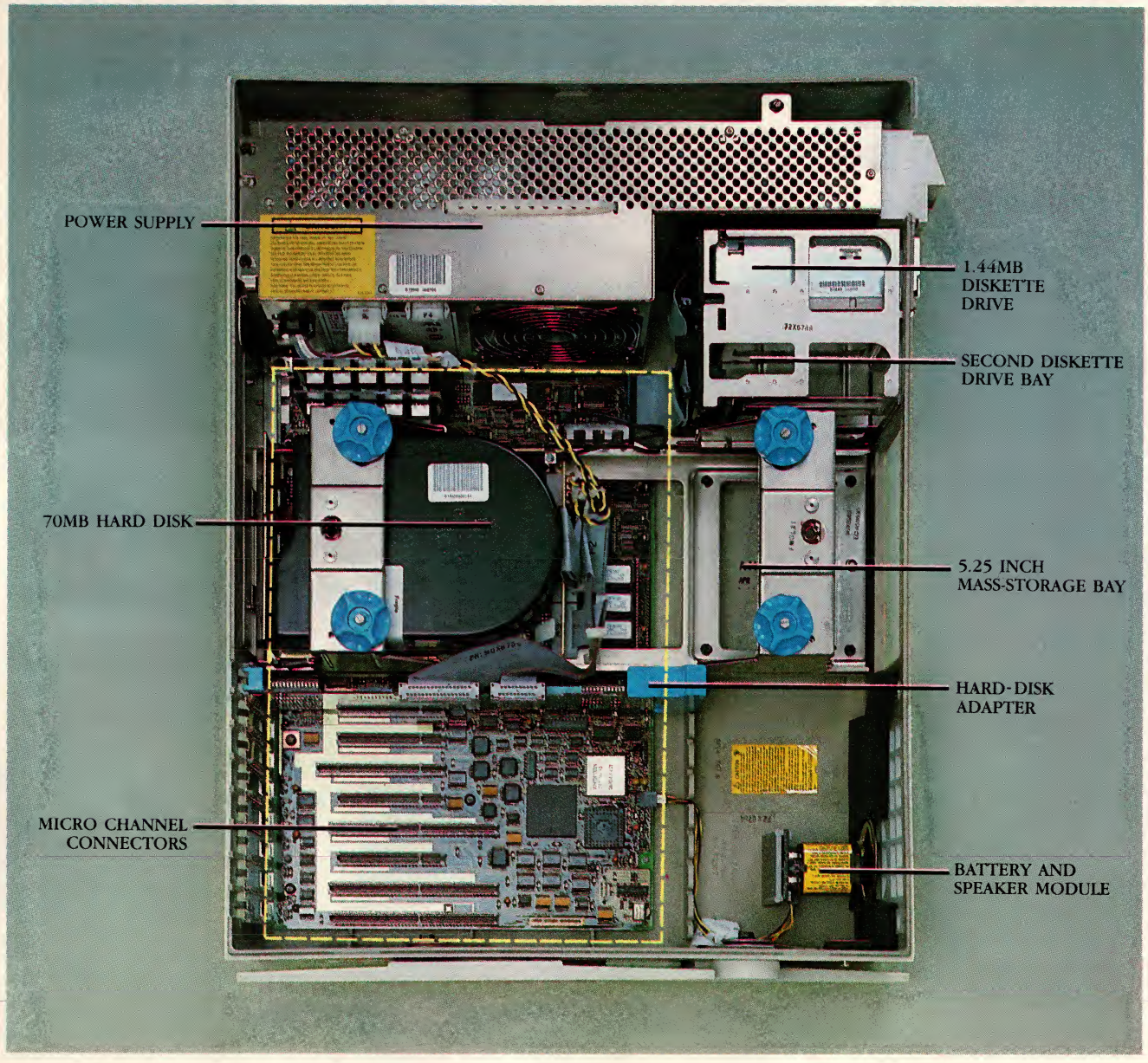
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PHOTO 1: *Inside the Model 80 System Unit*



The dotted outline indicates the location of the system board. The power supply sits along the top. Underneath and to the right are the 3.5-inch drives, with room for two hard disks below. The RAM cards fit into special slots above the hard disk.

trast to earlier IBM models and most other 80386 machines, the Model 80 uses 32-bit-wide ROM to store the BIOS. Thus, the 80386, which can access 32 bits of data in one instruction, can get the full 32-bits in one memory access, rather than using two or four, as would be required if the data path to ROM were 16 or 8 bits. The Model 80 RAM boasts 80-ns access times, compared to the 150-ns AT variety.

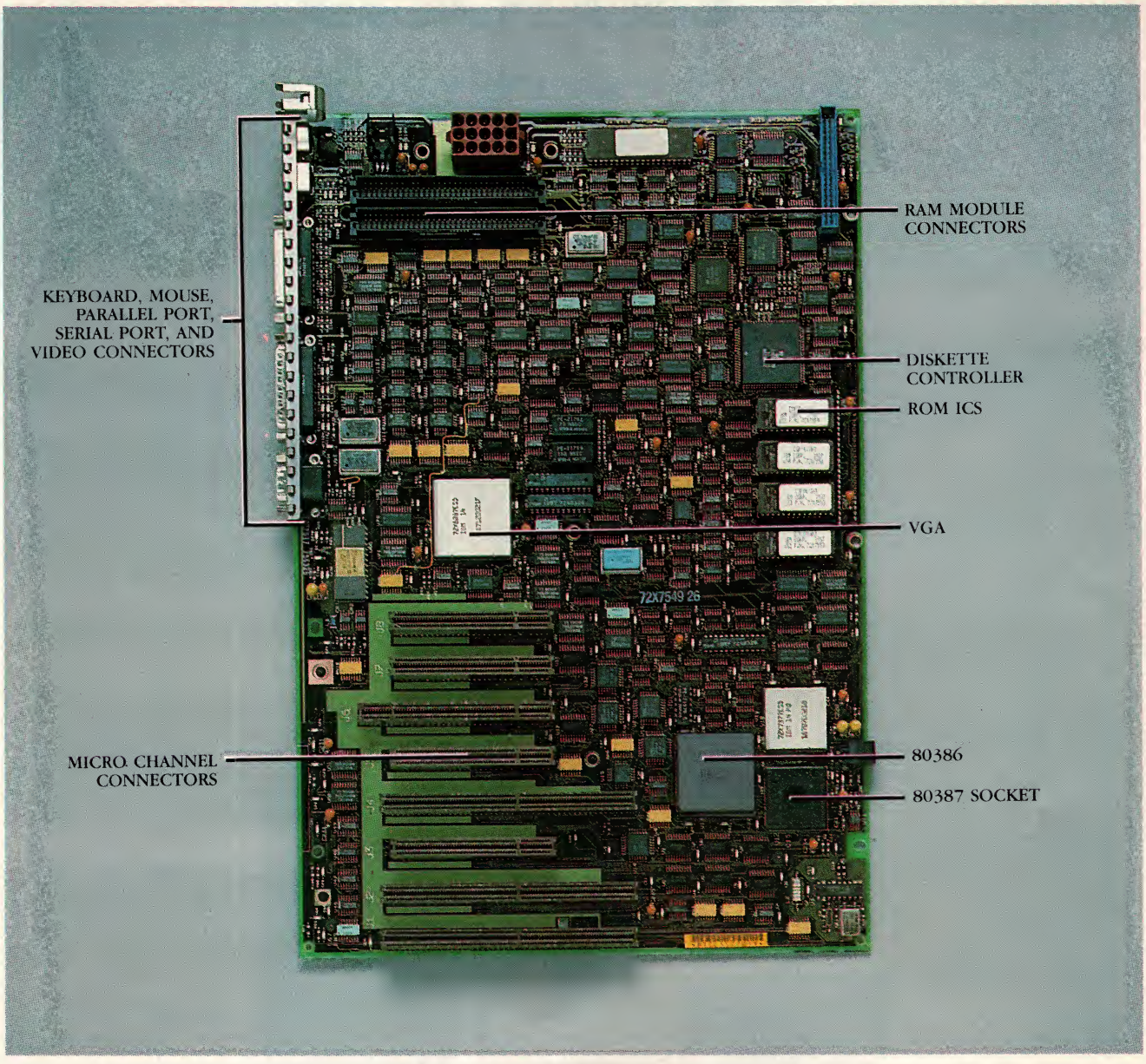
Other new extras include a disk-caching program, an advanced audio system, and expanded password protection to prevent unauthorized use of the machine. The password feature has three levels that restrict access. The first prevents the machine from being rebooted without a password, the second can act as a lock for the keyboard without stopping the processor, and the other allows the machine to be rebooted after a power failure. (See "New-Generation ATs.")

The disk-caching program runs under DOS and uses conventional memory or a portion of extended memory for the cache, which is managed as a write-through, least-recently-used algorithm. The cache is installed by running IBMCACHE.COM from the Reference Diskette. This program copies IBMCACHE.SYS to hard disk C: and, according to options selected from a menu, modifies CONFIG.SYS to include or delete the IBM cache device driver. The cache cannot be turned on or off without changing CONFIG.SYS and rebooting. It is surprising that the cache program is a hidden file. (See "The Cache Factor," Maxine Fontana, p. 168, for details on the IBMCACHE and its effect on performance.)

EASY DOES IT

Almost everything about the installation of these machines is an improvement over the AT. Virtually no tools are required to open the machine and install option cards or drives, and it has no switches to set. Once the key lock has

PHOTO 2: *Model 80 System Board*



The hard-disk controller is located in the first expansion slot and can support two hard disks. The third slot has extra lines to enable video adapters to communicate with the VGA on the system board. The fifth, seventh, and eighth slots are 32-bit slots.

been turned to the open position, the cover of the system unit (its left side) is removed easily. The two large screws holding it can be loosened with a few turns of a large, flat-blade screwdriver. The cover pops off easily, but putting it back on takes some practice because the bottom part needs to slide over a lip at the bottom of the system unit.

The 225-watt power supply that runs across the top of the system unit automatically senses the voltage being applied and switches between 115 volts 60 Hz for the US supply and 240 volts 50 Hz for European requirements. Immediately beneath it on the right is the 3.5-inch drive bay. The 3.5-inch drives can be installed and removed easily without the usual fumbling for data and power cables, because all cables are fixed to the drive enclosure itself. After the front panel is popped off, installing a drive involves simply sliding it into the enclosure while holding the connector at the rear of the enclosure. The drive's connector snaps into the connector fixed on the drive enclosure—this single connector links both the power and drive signals. Removal of the drive involves pressing a small release catch at the rear of the enclosure while pressing the release catch at the front of the drive and pulling the drive forward.

The hard disks are mounted beneath the 3.5-inch bay. Each drive mounting is held in place by two large blue knobs that can be tightened and loosened easily by hand. These knobs tighten clamps on either side of the hard disk that prevent the disk from being moved along its mounting rails. The drives require the normal drive and power cables, but with the spacious Model 80, these also can be attached and disconnected easily.

The system board, situated against the right-hand panel of the system unit, is approximately the same size as the AT's, but is similar in configuration to the Model 60's. It extends from the

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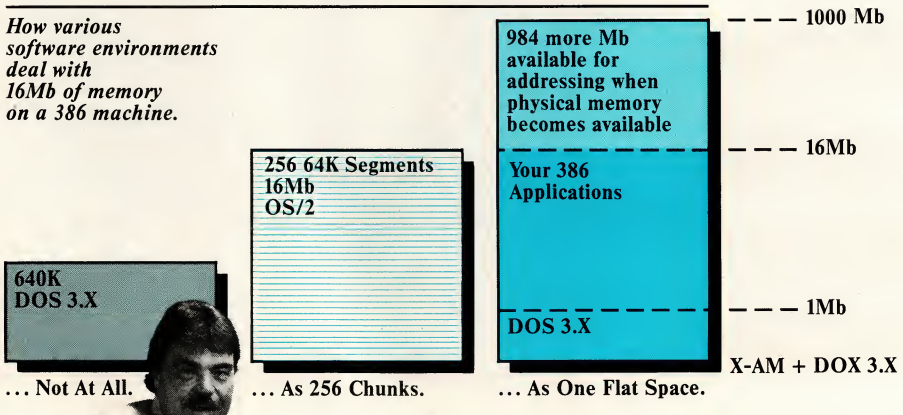
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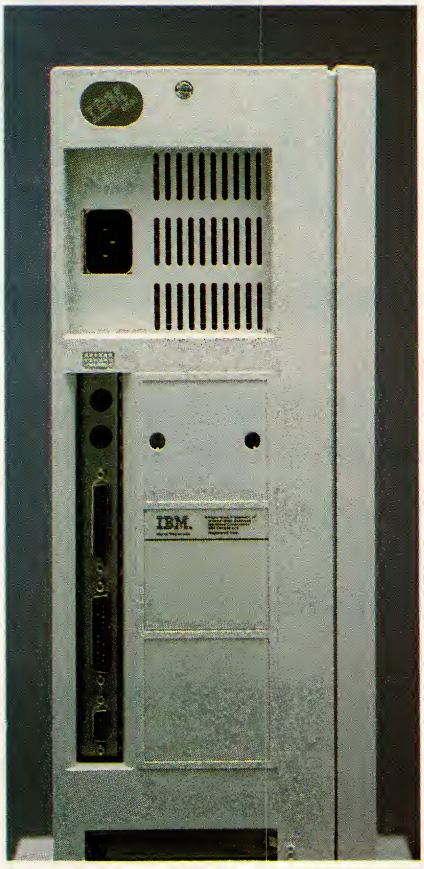
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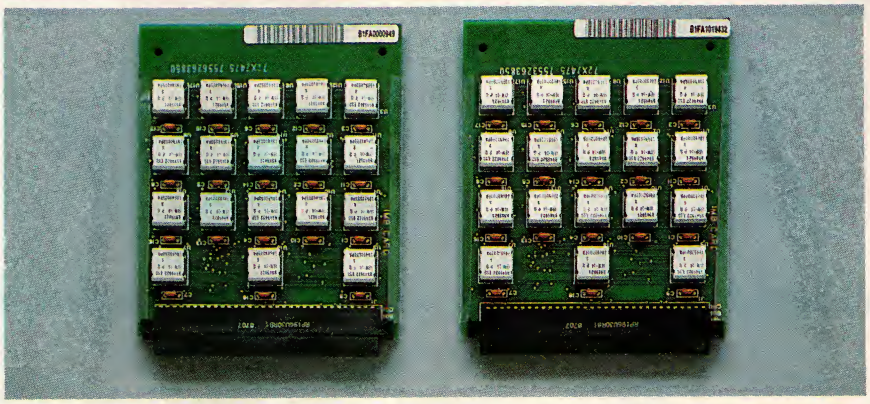
CIRCLE NO. 184 ON READER SERVICE CARD

PHOTO 3: *Top of Rear Panel*



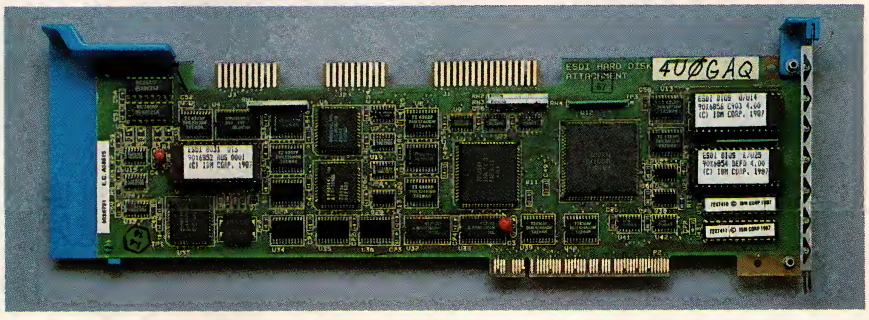
The two small connectors are for the keyboard and mouse. Below are parallel, serial, and display connectors.

PHOTO 4: *Memory Modules*



The memory on the local bus is situated in memory modules that are placed into connectors on the left side of the system board just above the hard disk.

PHOTO 5: *Hard-disk Controller*



The hard disk on the Model 80 has an enhanced small device interface (ESDI). The board-removal handles make the board easy to install and remove, although mechanically, the expansion boards in the PC were much better supported.

base of the power supply to the bottom of the system unit. The 80386 and the 80387 are located on the lower right corner of the board. The system board memory is located on two carriers—RAM miniboards (see photo 4), each containing 1MB of memory on the reviewed 16-MHz unit. These units mount vertically into the memory expansion connector located on the left side of the system board just above the hard disk. A single RAM miniboard is supplied with the machine and an additional 1MB can be added without using any expansion slots. This Model 80 machine is expandable to a full 16MB by the use of boards on the Micro Channel bus.

IBM's Micro Channel cards offer additional conveniences for installation and removal of boards that are especially helpful in a crowded system. Each board, including the hard-disk controller shown in photo 5, has two blue handles. The handle near the rear bracket is the *holder*; at the opposite end is the *retainer*. Even so, the boards are not well supported in the center of the unit; at that end, they depend on foam attached to the cover to prevent them from flapping about. Mechanically, the expansion cards in the PC series were much better supported. Overall, the trade-off for easier insertion and removal is a good one.

Below the hard disks are the expansion slots. In addition to using a new bus interface, the slot covers are also different. Photo 6 shows the slot covers as viewed from the outside of the system unit. The covers are tightened or loosened using the black metal knobs located to the left of each. These knobs can be turned either by hand (a strong one) or using a screw driver. Once the knob has been loosened, the cover can be slid out a quarter of an inch or so and popped inward to be removed. Then, an expansion card can be slid into the slot and secured. These rear brackets are different from the AT's and are isolated from the ground on the board in order to reduce current loops and resultant EMI.

The battery and speaker module are located beneath the disk drive bay at the front of the unit. The PS/2 family has a more advanced audio system than the PC, and the speaker can be driven directly from the Micro Channel.

The Model 80 has a fan at the base of the power supply. Air is pulled in from the top of the unit through the power supply, down over the expansion boards. Then it is routed out of the ventilation grill at the lower side and front of the unit through a plastic scoop arrangement (see photo 7). Thus, air is blown out at foot level instead of knee level—a wise choice for a unit obviously meant to be placed under a working surface.

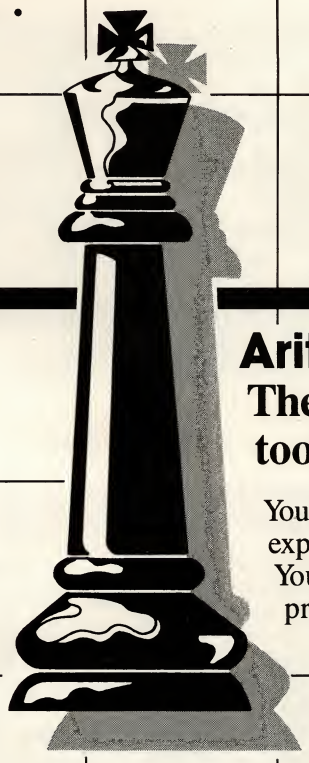
INSIDE OF AN 80

The Model 80 system board has eight slots: three 32-bit, four 16-bit, and one 16-bit slot with an auxiliary video extension. The topmost two are 16-bit slots, with the 8-bit portion on the left and the smaller 16-bit portion on the right. The third slot from the top (the one with the video extension) is intended for video adapters. The video extension enables a card that is in that slot to communicate with the video subsystem on the system board. The extra signals that are required for the

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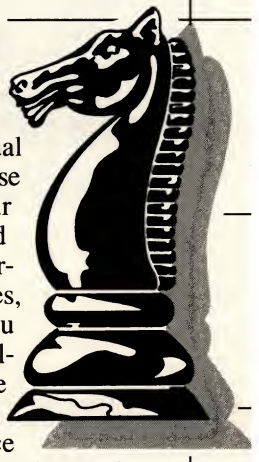


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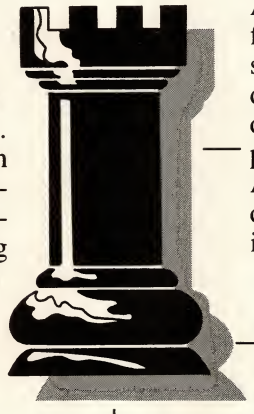
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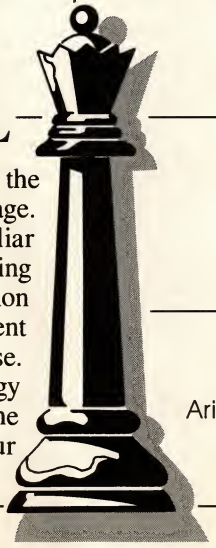
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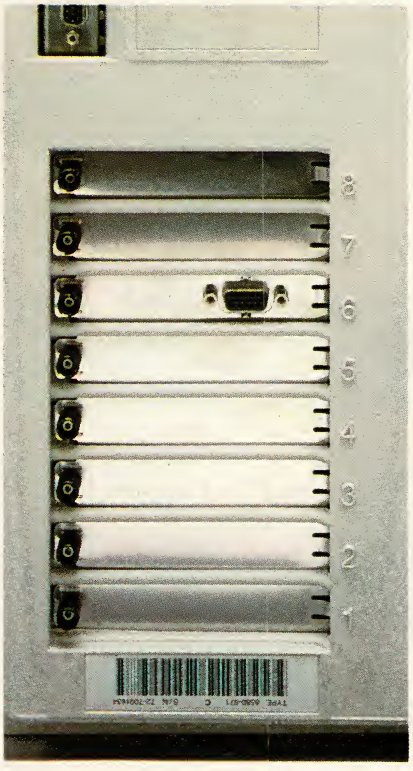
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PHOTO 6: *Slot Covers*



The black knobs located at the base (left) of each slot fasten or loosen the covers (or expansion cards).

PHOTO 7: *Ventilation System*



The scoop in the cover channels air from the power supply over the expansion slots and out the bottom.

video expansion extend the slot to the left noticeably farther than the other slots on the system board.

The fourth and sixth slots are additional 16-bit slots; the fifth, seventh, and eighth slots are 32-bit. As photo 2 shows, the 32-bit slots extend farther to the right than the 16-bit slots, but they also extend slightly farther to the left. The extension on the right is for the additional address and data lines. The small extension on the left includes the four lines used for the Matched Memory protocol. These lines permit intelligent 32-bit cards to increase the transfer speed over the bus; they are not present on the 16-bit slots. In the tested configuration, the disk controller occupied the top 16-bit slot and the other seven slots are vacant.

By using the Matched Memory protocol lines, a fast processor can query a memory card to see if the memory is capable of operating at a faster rate than the basic cycle time. The minimum cycle time on the 16-MHz Model 80 is 250 ns, as it is the nearest multiple of the clock rate to 200 ns. The MMC allows this time to be reduced by a clock cycle to 187 ns. The MMC must be requested on a cycle-by-cycle basis to gain the additional speed. Three signals are supplied on the Micro Channel. The MMC signal is for the system microprocessor controlling the bus to signal that it is capable of running a MMC. The Matched Memory Cycle Request (MMCR) is driven by a slave board to request a faster cycle on the system bus. When the data are valid on the bus during a MMC, the MMC Command (MMC CMD) is generated by the 80386.

The logic circuitry on the Model 80 system board provides a mechanism whereby a 16-bit data master on the Micro Channel can communicate with 32-bit data slaves. Four byte-enable signals, which normally are used by 32-bit slaves, are generated by the system when a 16-bit master is controlling the bus. With a 32-bit master, these are usually generated by the master itself.

OPERATING OPPORTUNITIES

Either DOS 3.3 or Operating System/2 (OS/2, not yet available) is required for the Model 80; each must be purchased separately. Cassette BASIC comes with the machine, but no manual is included. DOS 3.3 comes with BASIC 3.3 and, again, the manual is extra. (See "Aging DOS," Julie Anderson, p. 180 for a discussion of the new version.)

The Model 80 Reference Diskette is similar in purpose and function to the Model 50/60 version. It contains a menu-driven guide to the system for novices, in addition to configuration software and IBMCACHE. The software and system diagnostics include the advanced diagnostics (invoked by pressing Ctrl-A at the option menu screen). Each time an option is installed in the system, for example a Token-Ring board, the machine's Reference Diskette should be updated. This provides the necessary adapter configuration files for the system in lieu of setting switches on expansion cards.

IBM has announced that OS/2 is the operating system of the future for the Model 80. The features of OS/2 (described in the sidebar "The Yellow Brick Road to OS/2" in "Aging DOS") include permitting the machine to be operated in 80286 protected mode. But OS/2 will not exploit the 80386; no current DOS-like operating system does. Until such an operating system is developed, the full power of the 80386 will remain untapped. In the meantime, the increasing availability of control programs that can use the virtual 8086 mode of the 80386, makes the machine viable. In addition to the operating system and language products mentioned above, IBM plans to provide the Advanced Interactive Executive (AIX) operating system and AIX languages VS Pascal, VS FORTRAN, and C for use on the Model 80. This system will be a subset of the operating system currently available on the RT PC. IBM plans to provide information regarding the price and planned availability of this group of products in the fourth quarter of 1987.

PERFORMANCE TESTING

The Model 80 went through the standard two-part examination. Its 32-bit bus implementation inhibited the first part of the tests, in which a series of software and hardware products are installed to check for compatibility. None of the usual expansion boards could be installed. In the second half, the Model 80 was run through the evaluation suite developed for *PC Tech Journal*'s "Out of the Shadow of IBM" series on AT compatibles. (The series began in the August 1986 issue. The modification of the tests to run on 80386-based computers is detailed in "Update on Performance and Compatibility Tests," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 70.) The results of the evaluation suite are shown in table 1, with com-

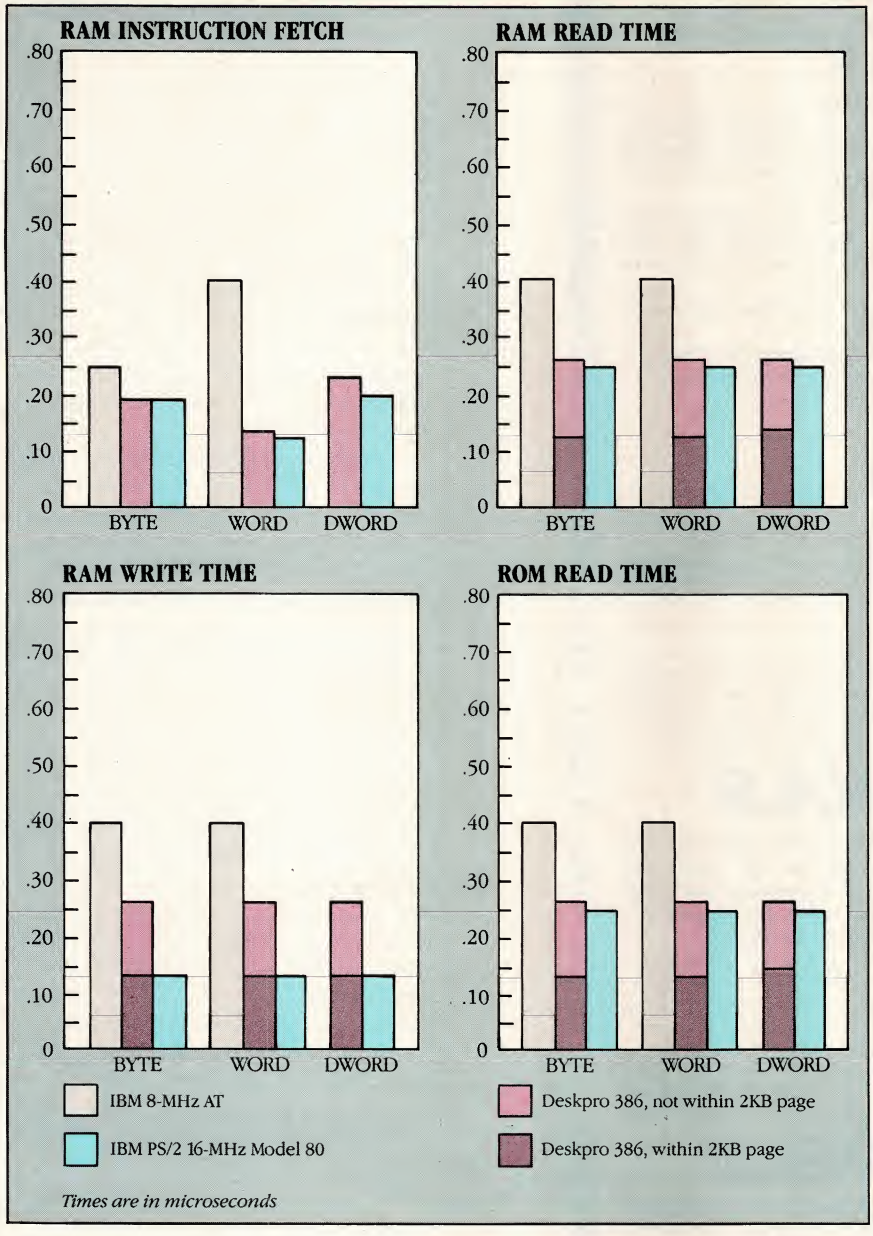
TABLE 1: *Compatibility and Performance Tests*

	8-MHz AT, 30MB DISK[a]	DESKPRO 386, 40MB DISK, 80387	16-MHz MODEL 80, 70MB DISK
ATBIOS			
ROM BIOS date	11/15/85	08/19/86	1987
ATPERF			
Average RAM instruction fetch (μs)			
BYTE	.25	.19	.19
WORD	.403 (100)[b]	.14 (280)	.13 (310)
DWORD	N/A	.23	.20
Average RAM read time (μs)			
BYTE	.401 (100)	.13/.26 (298/154)	.25 (160)
WORD	.401 (100)	.13/.26 (298/154)	.25 (160)
DWORD	N/A	.14/.26	.25
Average RAM write time (μs)			
BYTE	.401 (100)	.13/.26 (307/154)	.14 (283)
WORD	.401 (100)	.13/.26 (307/154)	.14 (283)
DWORD	N/A	.13/.26	.14
Average ROM read time (μs)			
BYTE	.401 (100)	.39 (102)	.25 (160)
WORD	.401 (100)	.39 (102)	.25 (160)
DWORD	N/A	.39	.25
Average CGA video write time (μs)			
BYTE	1.208 (100)	1.21 (100)	N/A
WORD	2.415 (100)	2.42 (100)	N/A
DWORD	N/A	4.83	N/A
Average EMM read time (μs)			
BYTE	.402 (100)	.13 (301)[c]	N/A
WORD	.402 (100)	.13 (301)[c]	N/A
DWORD	N/A	.14[c]	N/A
Average EMM write time (μs)			
BYTE	.402 (100)	.13 (306)	N/A
WORD	.402 (100)	.13 (306)	N/A
DWORD	N/A	.13	N/A
CPU clock rate (MHz)	8.0 (100)	16.0 (200)	16.0 (200)
Math coprocessor clock rate (MHz)	5.3 (100)	16.0 (200)	16.0 (200)
Refresh overhead (%)	7.1	14.9	4.0
RAM read wait states	1	0	2
RAM write wait states	1	0	0
ROM read wait states	1	4	2
Video write wait states (CGA)	8	17	N/A
EMM read wait states	1	0[c]	N/A
EMM write wait states	1	0[c]	N/A
ATFLOAT			
Performance as percentage relative to AT	100	630	590
ATDISK			
Sectors/track	17	17	32
Heads	5	5	64
Cylinders	731	978	69
Total space (million bytes)	31.81	42.56	72.35
Track-track seek time (ms)	6.0	4.1	14.1
Average seek time (ms)	37.1	27.6	33.1
Effective transfer rate (KB/sec)	170.1	254.5	479.1
DOS file I/O (sec)[d] (with/without cache)	7.3	5.5/8.0	11.4/12.7
Interleave	3	2	1

[a] *The figures for the IBM AT are the average results from several machines, whereas the results from the Compaq Deskpro 386 and IBM PS/2 Model 80 are taken only from the review sample model.*
[b] *Figures shown in parentheses represent the relative performance expressed as a percentage compared to* PC Tech Journal's *baseline machine, the 8-MHz, 30MB AT.*
[c] *EMM measurements were taken using the Deskpro 386's built-in memory configured as expanded memory with the CEMM driver.*
[d] *The Compaq Deskpro 386 was tested with and without the Compaq disk-caching program and the IBM Model 80 was tested with and without IBMCACHE.*

The PS/2 Model 80 had not been released when this review was conducted, thus an exact ROM BIOS date was not available.

FIGURE 1: *Performance Comparison*



The Micro Channel architecture prohibited testing the Model 80 with AT-compatible add-in boards; however, most of the software tested ran well. ATDISK showed the 70MB drives to be high-performance units appropriate to such a machine.

parison figures for an 8-MHz AT (the standard against which all computers normally are measured) and the Compaq Deskpro 386 with an 80387, perhaps the more interesting comparison.

The hardware products that could be tested with the Model 80 were an 80387 (already installed), a Microsoft serial Mouse, and an IBM Mouse. IBM's VGA video interface also was tested with a 8512 color monitor. (The communications programs and a modem, which usually are part of the evaluation, could not be included because telephone lines were not available in the room provided for testing.)

All of these products worked in the Model 80, almost without incident. Even though the IBM Model 80 has an interface for its own Mouse, the Microsoft Mouse worked with both Windows and Word. With the Model 80's floor-standing system unit, the cable on the Microsoft Mouse seems short, although the mouse worked normally.

The software tested include Microsoft Windows 1.01 and Microsoft Word 3.1 to test graphics and the mouse. Borland's SuperKey 1.11A, SideKick 1.56A, and Turbo Lightning 1.101A, plus Living Videotext's Ready! 1.00D, were used to evaluate memory-resident pro-

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grams. (Ready! was used in conventional memory only because an expanded memory board was not available for the Model 80.)

All of the programs worked without error except Microsoft Word. When Word 3.1 was used with the Microsoft Mouse and the 8512 color monitor, Word recognized that the VGA/8512 combination was capable of EGA resolution, so it was able to display high-resolution characters in graphics mode, and show on-screen italics, underlining, and boldface, as well as using the various graphic symbols for the mouse. But it was only able to do so using two colors: a dark blue background with light blue characters.

Attempts to switch colors revealed that Word recognized only those two colors. When the IBM Mouse was used instead of the Microsoft Mouse, Word ran correctly and was able to use the full range of colors. At the same time these tests were going on, duplicate problems emerged with the Model 60 at the editorial offices. A newer version of Microsoft Word (3.11, April 1987), released since testing and available on 3.5-inch diskettes, has eliminated the problem on the Model 60. It is probably safe to assume that this is also true for the Model 80 (although *PC Tech Journal* was not able to test it), since the video interface is common to the two machines. Indeed, Microsoft Windows, another graphics-oriented program, worked normally, with resolution and colors compatible to those provided by the EGA, regardless of which mouse was connected to the system.

The compatibility and performance tests consist of five programs: ATBIOS checks the BIOS and BIOS data areas. ATKEY checks for keyboard compatibility. ATPERF measures CPU and math coprocessor clock rates, as well as memory access times. ATFLOAT measures floating-point operations with the math coprocessor installed. ATDISK measures hard disk performance.

ATBIOS showed that the Model 80 uses the BIOS data area in the same way that the AT does. Of course, the BIOS lists an IBM copyright and a 1987 copyright date. ATKEY verified the keyboard compatibility, enabling the keyboard to repeat at 30 characters per second with a quarter-second delay.

ATFLOAT revealed that the Model 80, with its 16-MHz 80387, can process floating-point operations almost 6 times as fast as an 8-MHz AT (which uses a 5.33-MHz 80287), but not quite as fast as the Compaq Deskpro 386 (with a 16-MHz 80387), which can process

floating-point operations more than 6 times as fast as an 8-MHz AT. This is an impressive performance that clearly shows the advantages an 80387 can offer over the 80287.

The 70MB drives in the Model 80 were shown to be the high-performance units appropriate for a computer of this power, by their execution of ATDISK. The Model 80's hard disks have an especially good effective transfer rate—approximately twice as good as that demonstrated by the Deskpro 386 drives. This performance betterment can be traced to the Model 80's ESDI disk controller, which performs well enough to enable IBM to format its drives with an interleave of 1. (For more information on the interleave factor, see the August 1986 article.)

With an interleave of 1, only one disk revolution is required to read (or write) a single track. The Deskpro 386 drives use an interleave of 2, requiring two disk revolutions to read a single track. The ESDI is used on all PS/2 series disks that have a capacity of 70MB or more (available only with Models 60 and 80). This interface uses relative block addressing for locating data on the disk rather than the absolute addressing used on smaller drives.

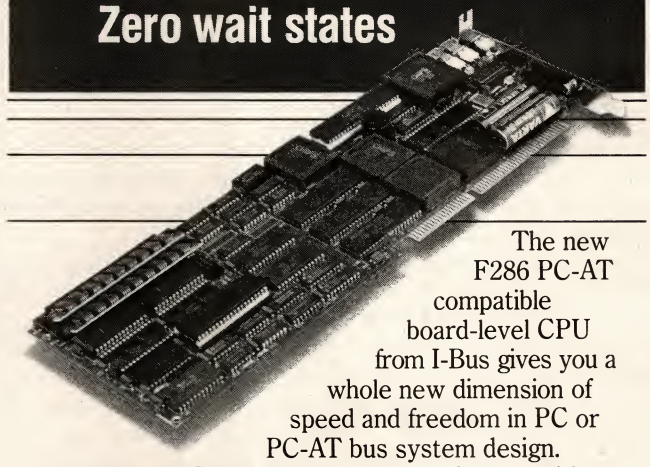
In order for the ESDI controller to perform the necessary conversions to extract the required relative block addressing information from the information supplied by the relevant DOS function call, the information that is given to the disk table about the number of sectors, heads, and cylinders that the disk has is incorrect. The information that DOS has translates into 2,048 sectors per cylinder; actually each cylinder has 248 sectors. Thus, track-to-track tests that step the head on the disk drive through DOS by what the test thinks is one track are actually stepping the head through about eight tracks, and so, are wrong. Any random track-track test will still be accurate because the exact number of tracks stepped across is not important in testing for average access times.

The DOS file I/O test, however, which reads, writes, and deletes ten 20KB files, ran slightly slower on the Model 80 than the Deskpro, even with the 80's disk cache active. The nature of the test (reading and writing many small files) inhibited the disk cache from having a beneficial effect.

Finally, ATPERF showed that Model 80 system performance is quite similar to the Deskpro 386. Average instruction fetch and RAM write times are almost identical. The video write time for the

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Model 80 is not relevant because it is not possible to run a CGA in the Model 80 machine. The emulation time for the VGA to run CGA is not a fair comparison of performance.

IN PRODUCTION

With its documentation for the PS/2 line, IBM moves in a new direction. Each member of the family boasts a high-quality reference guide. The small book that accompanies the Model 80 Reference Diskette explains setting up the system and installing options such as a second disk drive or the math coprocessor. The one exception is the documentation for the disk cache—one loose sheet of paper, supplied with only *one* of the machines reviewed.

A separate *IBM PS/2 Model 80 Technical Reference* is available, while the *IBM Personal Computer and PS/2 BIOS Interface Technical Reference* covers the range of machines. The Model 80 reference merits special mention: it is a considerable improvement on the PC and AT references. For one thing, it is better organized, not the hodge-podge of technical specifications like some early manuals. In addition, it explains extremely technical information in terms that even a less-sophisticated user can understand.

On the other hand, this manual might be incomplete. The quality varies between sections almost as if each had been written by a different group within IBM. The Micro Channel section is very well done. It obviously is designed to encourage developers to build Micro Channel boards, but it includes no schematics that would permit trouble-shooting or repair at a component level. The BIOS manual no longer provides listings as the AT manual did; in addition, it describes only those functions available and the result of using them. The philosophy of providing a simpler user interface, which is so apparent in the hardware of these machines, has obviously been applied in the documentation as well. This is something the more sophisticated user will appreciate.

IBM provides a one-year, limited warranty for the Model 80. Extended service contracts are also available from the company and its authorized dealers. But because of the improved design delivered by the Micro Channel architecture, making error detection so much easier for diagnostic and service programs, IBM has lowered the price of its service contracts for the Model 80 and other Micro Channel systems. The annual contract for a Model 80 with a 44MB hard disk is $220 (compared with $546 for the AT Model 339).

The Model 80 is a computer system with one foot in the present and the other decidedly in the future. The 16-MHz machine tested here offers performance that matches any personal computer on the market and the 20-MHz version could surpass that. It offers excellent software compatibility for the present, and, with its IBM name, any software that does not run on the Model 80 probably will be modified to do so soon.

The biggest strike against the Model 80 at this time is that the Micro Channel architecture prohibits the machine from accepting the multitude of add-in cards now available for the AT and compatibles. Of course, this should be balanced against the greatly reduced need for such cards, as a result of the Model 80's many standard features. For whatever time period ensues, purchasers of the Model 80 simply will be limited to add-in cards provided by IBM.

If the consideration is the performance of machines as they currently can be configured, the Model 80's direct competition is the Compaq Deskpro 386 (which may be more cost-effective in the current state of affairs). This probably will change with the emergence of boards designed for the Micro Channel architecture, an operating system (as yet unannounced) that exploits the new system design, and applications software written to that new operating system.

More importantly, the new architecture, although currently incompatible, hold great promise. Its ability to support faster bus cycles with the Matched Memory protocol makes it a legitimate base for even higher performance microprocessors in the future. Its capacity to handle multiple bus masters in a single system will promote the development of intelligent controllers, such as network boards and micro-to-mainframe boards, that will off-load much of the work that systems now must do to support those functions. Switchless option selection and advanced error detection capabilities will offer many additional benefits.

This is a machine with outstanding potential for the future that delivers top-quality performance today. When OS/2 finally arrives, it will be better able to take advantage of the power of the Model 80's 80386. Looking ahead even farther, an operating system that takes full advantage of this microprocessor could make the IBM PS/2 Model 80 an even better investment.



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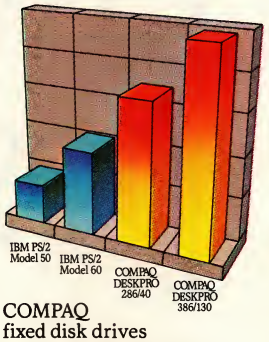
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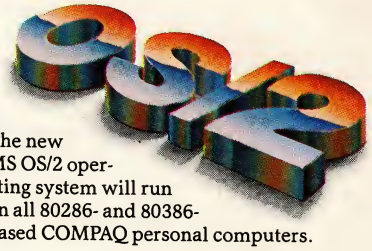
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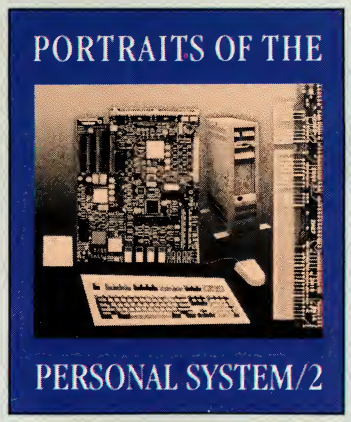
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PS/2: The Market Context

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Until recently, buying an IBM personal computer was like special-ordering a new American car used to be. Want a stick shift but not air conditioning? Can you do without overdrive? And will that be a V-8 or a V-6? Two-tone blue or blue with a vinyl top? And the color of the vinyl?

Configuring a personal computer system involved a comparable set of decisions at every turn. There were disk drive decisions, both floppy and fixed. There were memory decisions and expanded memory decisions, parallel and serial port decisions, and graphics decisions—boy, were there graphics decisions, not to mention display decisions. There were even those knotty clock/calendar decisions.

All that has changed. Buying a computer in the Personal System/2 line is more like buying a Japanese car: once you choose the model, the only decision left to make is color; once you decide to buy into the PS/2 line, the only decision to make is which of the four new displays (three color and one monochrome) to attach to the system. Nearly all of the other technical decisions have been eliminated.

Four new models were announced in April, and three of them were actually rolled out onto the showroom floor: Models 30, 50, and 60. Model 80, the 80386 workstation product, arrived in June. Models 30 and 50 are desktop computers; 60 and 80 are floor-standing units, a la the RT PC. Deciding among them depends largely on disks and money: how big and how much. Table 1 lists the details of all the systems; part numbers and prices of all the major products announced along with the PS/2 machines are listed at the end of this article.

Context is very important in evaluating PS/2 computers: how do they compare to each other, to the PC line, and to the competition? Table 2 compares similarly configured systems of both IBM and the competition. In order to make equivalent comparisons among systems, we added the following elements to the base configuation: adaptable-sync color monitor ($570), 256KB EGA-equivalent board ($350), and 512KB memory board to provide an additional port ($450). Because a graphics subsystem is included in each PS/2 machine, we had to add only the PS/2 8513 color monitor ($685) to complete each PS/2 configuration.

STARTING SLOW

Dealers of IBM machines openly applauded when the Model 30 was announced back in April, probably because of price ($1,695, or $2,295 with a 20MB hard disk) and because it appeared to be suited for use in homes,

At this moment, price and performance comparisons between the PS/2 line and its competition may provide no compelling reason to switch to the new IBM models; but the future may tell a different story.



schools, and possibly as secretarial workstations. Two months later, as this article was being written, dealer cheers were replaced by these words from a Businessland executive: "Slow start for the 30." He predicted a marketing effort directed to boost its slow sales; others predicted lower prices.

A small sampling of the education market told a different story: for example, the initial order for PS/2s by one large technical university was for 35 machines: thirty of them were Model 30s; the other five were divided between Model 50s and 60s. A university spokesman called the Model 30 "a fair student machine because it's priced right," but said it faces an uphill climb to overtake the Macintosh as the students' computer of choice.

IBM describes the Model 30 as providing "enhanced function at a lower cost than the IBM Personal Computer or IBM Personal Computer XT." It is an 8086-based, 8-MHz machine with 640KB of RAM; a color graphics subsystem called the Multi-Color Graphics Array (MCGA); three ports for serial, parallel, and pointing devices; and three PC-bus expansion slots. Because of its foot in the old 8086 processor camp and its lack of the new Micro Channel bus, the Model 30 cannot be considered a full member of the PS/2 family. It also does not have the new Video Graphics Array (VGA) although all the new displays can be used with this model.

The Model 30 is available with two 720KB 3.5-inch diskette drives or with one 720KB, 3.5-inch diskette drive and one 20MB hard disk. For a detailed analysis of the Model 30 see "Model 30: Apart from the Family," Ted Mirecki, this issue, p. 92.

Because the supply of PC/XTs has all but dried up except in educational institutions, price comparisons to the Model 30 are largely theoretical: an XT Model 089 with 640KB, CGA, the IBM RGB display, serial and parallel ports, and a 20MB hard disk lists for $3,484. The Model 30 with a 20MB drive and the 8513 display lists for $2,980. As Will Fastie points out in "What IBM Did Right and Wrong, Part/2," (this issue, p. 46), the Model 30 has "roughly twice the performance of an XT and much better graphics for 17-percent less." Another machine for comparison is the AT&T 6300, which has an 8086, 20MB hard disk, 640KB, serial and parallel ports, CGA-compatible graphics, color display, and a clock-calendar with a list price of $2,108 (see table 2).

THE CLEAR WINNER

Adding $1,300 to a "monitorless" Model 30 will buy the Model 50 box ($3,595) and a clear pedigree in the PS/2 family. The Model 50 is an 80286, 10-MHz desktop machine with one 1.44MB, 3.5-inch diskette drive, 20MB hard disk, the new Micro Channel Architecture, VGA, three expansion slots, and three ports. IBM press information describes the Model 50 as "combining many features previously available as options in a low-cost, business-oriented configuration."

Dealers have not been disappointed with this machine; all dealers contacted for this article named the Model 50 as an early and clear favorite of the business buyer. Senior technical editor Jim Shields calls the Model 50 and its close relation the Model 60, "the new generation of IBM ATs" and says that they "improve on the AT in almost every way." (His technical analysis of the Models 50 and 60 appears in "Models 50 and 60: New-Generation ATs," this issue, p. 110.)

To place the Model 50 in context, compare it with the Apple Macintosh SE and the XT 286 and AT 339. The basic Model 50 with IBM mouse and monochrome display lists for $3,940; the Mac SE for $3,698. The price difference between the Model 50 and the Mac buys three expansion slots on the Model 50 versus one on the Mac; another $325 invested in the Model 50 for a monitor yields color, an option that is lacking on the Mac.

ILLUSTRATION • JANE STERRETT

The XT 286, as configured in table 3, lists for about $4,177 and offers considerably less raw performance than the Model 50. The AT 339, which does offer somewhat better raw disk performance over the Model 50, lists for $5,962 in this standard, enhanced color graphics and display configuration.

LIGHT AT THE TOP

The two systems at the top of the PS/2 line, Models 60 and 80, do not fare as well with the competition as the Model 50 does. First a word about the systems themselves is in order.

Mass storage and expansion potential set the Model 60 apart from the Model 50. The floor-standing Model 60 comes in two configurations, one with a 44MB hard disk (60-041) and the other with a 70MB disk (60-071); base prices of these configurations are $5,295 and $6,295, respectively. Like the Model 50, the Model 60 is an 80286, 10-MHz machine with VGA and Micro Channel. The Model 60 has seven 16-bit expansion slots, whereas the Model 50 has three.

To place the Model 60 in context, consider the AT 339, the AST Premium/286, and the Compaq Deskpro 286 and note that the comparison earns a thumbs-down vote in the aforementioned "Right and Wrong" article. As Fastie points out, a machine like the Model 60 with a 10-MHz processor, one-wait-state memory, noninterleaved disk and cache software, and base prices of $5,295 (44MB disk) and $6,295 (70MB disk) has stiff competition from the AT and compatibles. The Premium/286, for example, has a 10-MHz processor and zero wait states, provides higher performance, and costs $3,990 (color display, EGA-equivalent graphics, and 40MB disk) or $4,690 (color display, EGA-equivalent graphics, and 70MB disk). Remember that the fully configured AT 339 compares at $5,962, and the Compaq Deskpro 286 with 40MB drive, color display, three ports, and EGA-equivalent graphics compares at $6,512.

At the top of the PS/2 line sits the Model 80, an 80386, 16-MHz machine available in two configurations: with 44MB hard disk (80-041) or a 70MB disk (80-071); and a 20-MHz machine scheduled to be available with a 115MB disk (80-111). The first two options were available in July, and the third option is not due until the fourth quarter of this year. Base prices for the Model 80s are $6,995, $8,495, and $10,995, respectively. IBM says the Model 80 is designed for "customers requiring higher performance and large storage, such as in engineering/scientific environments." Technical editor Caroline Halliday and contributing editor Steven Armbrust provide a technical analysis of the Model 80 and its performance in "Model 80: Performance and Potential" (this issue, p. 138).

TABLE 1: *PS/2 Configurations*

	30-002	30-021	50-021
Price	$1,695	$2,295	$3,595
Date available	Now	Now	Now
Processor	8086 8 MHz	8086 8 MHz	80286 10 MHz
Hard disk	No	20MB	20MB
Diskette drive (3.5-inch)	720KB 2 drives	720KB 1 drive	1.44MB 1 drive, 2nd optional
System RAM	640KB	640KB	1MB
System ROM	64KB	64KB	128KB
Maximum system memory	640KB	640KB	7MB
Graphics subsystem	MCGA	MCGA	VGA
Graphics—maximum resolution	640-by-480	640-by-480	640-by-480
Graphics—full color	300-by-200	300-by-200	320-by-200
Text mode	640-by-400	640-by-400	720-by-400
Bus	PC bus 8-bit	PC bus 8-bit	Micro Channel 16-bit
Ports	Keyboard, serial, parallel, pointer	Keyboard, serial, parallel, pointer	Keyboard, serial, parallel, pointer
Diskette controller	Included on system board	Included on system board	Supports 2 diskette drives
Disk controller	N/A	ST506	ST506
Available Expansion Slots	3 (8-bit)	3 (8-bit)	3 (16-bit)
Keyboard	Enhanced	Enhanced	Enhanced
Design	Desktop	Desktop	Desktop
Power supply (wattage)	70	70	94
Clock	Time/Date	Time/Date	Time/Date
Weight (pounds)	15.7	15.7	21
Depth (inches)	15.6	15.6	16.5
Width (inches)	16	16	14.1
Height (inches)	4	4	5.5
Electrical	90-265 V 50-60 Hz	90-265 V 50-60 Hz	90-265 V 50-60 Hz

The two Model 30s may be most attractive for home use and in schools. Model 50, with its clear PS/2 pedigree, is the leader in the marketplace at present.

The 44MB configuration of the Model 80 has 1MB of RAM; the 70MB and 115MB configurations each have 2MB of RAM. All are expandable to 16MB and include the VGA, Micro Channel bus, and a 1.44MB, 3.5-inch diskette drive. Seven slots are available on the Model 80: four are 16-bit slots and three are 32-bit slots.

The Model 80 arrives in a market crowded with the Compaq Deskpro 386 and a host of other competitors, including Apple, which offer big price advantages over the Model 80. The Deskpro 386's base prices of $6,499 (40MB hard disk), $7,299 (70MB disk) and $8,799 (130MB disk) will clearly keep it in strong competition with the Model 80. Sun Microsystems' workstation, the Sun 3/50, is $7,995 configured with a 71MB hard disk, and has both networking and windowing.

The Sun marketing people are only too happy to provide a feature-by-feature comparison of a fully configured 3/50 to the Model 80, showing the latter in poor light in terms of both price and functionality. A $7,995 configuration of the 3/50 includes a 68020 processor at 15 MHz, 19-inch mono-

60-041	60-071	80-041	80-071	80-111
$5,295	$6,295	$6,995	$8,495	$10,995
Now	Now	Now	Now	4th quarter '87
80286 10 MHz	80286 10 MHz	80386 16 MHz	80386 16 MHz	80386 20 MHz
44MB, 2nd optional	70MB, 2nd optional	44MB	70MB	115MB
1.44MB 1 drive, 2nd optional	1.44MB 1 drive, 2nd optional	1.44MB 1 drive, 2nd optional	1.44MB 1 drive, 2nd optional	1.44MB 1 drive, 2nd optional
1MB	1MB	1MB	2MB	2MB
128KB	128KB	128KB	128KB	128KB
15MB	15MB	16MB	16MB	16MB
VGA	VGA	VGA	VGA	VGA
640-by-480 320-by-200 720-by-400	640-by-480 320-by-200 720-by-400	640-by-480 320-by-200 720-by-400	640-by-480 320-by-200 720-by-400	640-by-480 320-by-200 720-by-400
Micro Channel 16-bit	Micro Channel 16-bit	Micro Channel 32/16-bit	Micro Channel 32/16-bit	Micro Channel 32/16-bit
Keyboard, serial, parallel, pointer	Keyboard, serial, parallel, pointer	Keyboard, serial, parallel, pointer	Keyboard, serial, parallel, pointer	Keyboard, serial, parallel, pointer
Supports 2 diskette drives	Supports 2 diskette drives	Supports 2 diskette drives	Supports 2 diskette drives	Supports 2 diskette drives
ST506	ESDI	ST506	ESDI	ESDI
7 (16-bit)	7 (16-bit)	4 (16-bit) 3 (32-bit)	4 (16-bit) 3 (32-bit)	4 (16-bit) 3 (32-bit)
Enhanced	Enhanced	Enhanced	Enhanced	Enhanced
Floor-standing	Floor-standing	Floor-standing	Floor-standing	Floor-standing
207	207	225	225	225
Time/Date	Time/Date	Time/Date	Time/Date	Time/Date
41.8	41.8	45.3	52	52
19	19	19	19	19
6.5	6.5	6.5	6.5	6.5
23.5	23.5	23.5	23.5	23.5
90-265 V 50-60 Hz	90-265 V 50-60 Hz	90-265 V 50-60 Hz	90-265 V 50-60 Hz	90-265 V 50-60 Hz

The two Model 60s and three Model 80s sit atop the new family. Model 60 improves on the AT in nearly every way; Model 80 is poised for the advent of OS/2.

chrome display, maximum system memory of 4MB, integrated thin Ethernet transfer, and 71MB hard disk. The base price of the 71MB Model 80 is $8,495, excluding display and including only 1MB of memory; $10,119 with a 16-inch color monitor.

DISPLAY DECISIONS

Because each of the four new monitors works with all the new members of the family, the choice among them is dictated not by the computer but by the needs and preferences of the user—that is, the choice is between a larger monitor with slightly larger images or a smaller monitor with sharper images. Three of the new displays are color and one is monochrome. (See "VGA: Evolutionary Half-Step," John Cockerham, this issue, p. 74 for an analysis of the VGA and the new monitors.)

At the high end is the 8514, a 16-inch monitor that will be of interest to users who need a large, high-resolution screen for CAD or special graphics applications. It can produce 256 colors at a resolution of 1,024-by-768 and lists for $1,550. At the low end is the monochrome monitor, Model 8503, a 12-inch monitor with 720-by-400 resolution in text mode and 640-by-480 in graphics mode. It lists for $250.

The other two color monitors produce the same number of colors, have the same resolution, and are very close to each other in price ($685 for the 8513 and $595 for the 8512). Size and

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TABLE 2: *Comparing PS/2s and the Competition*

MODEL 30 COMPARISON[a]	MODEL 30	XT 089	AT&T 6300
Price	$2,980	$3,484	$2,108
Hard disk	20MB	20MB	20MB
Graphics subsystem	MCGA	CGA	CGA

MODEL 50 COMPARISON[b] (monochrome)	MODEL 50	MACINTOSH SE
Price	$3,940	$3,698
Hard disk	20MB	20MB
Graphics subsystem	VGA	Monochrome

MODEL 50 COMPARISON[c] (color)	MODEL 50	XT 286	AT 339
Price	$4,280	$4,177	$5,962
Hard disk	20MB	10MB	30MB
Graphics subsystem	VGA	EGA	EGA

MODEL 60 COMPARISON[d]	MODEL 60	PREMIUM/286	DESKPRO 286	AT 339
Price	$5,980	$3,990	$6,512	$5,962
Hard disk	44MB	40MB	40MB	30MB
Graphics subsystem	VGA	EGA-equivalent	EGA-equivalent	EGA

MODEL 80 COMPARISON[e]	MODEL 80	SUN 3/50	DESKPRO 386	MACINTOSH II
Price	$8,545	$7,995	$7,098	$6,996
Hard disk	44MB	71MB	40MB	40MB
Graphics subsystem	VGA	Monochrome only	EGA-equivalent	EGA-equivalent

[a] *Configurations include 640KB, hard disk and graphics subsystem as specified and color monitor. AT&T and XT systems have only two ports; the Model 30 has three.*
[b] *Configurations include mouse and monochrome monitor.*
[c] *Configurations represented have 640KB, hard disk and graphics subsystem as specified, color monitor, two serial ports, and one parallel port.*
[d] *Configurations represented have 640KB, hard disk and graphics subsystem as specified, color monitor, two serial ports, and one parallel port.*
[e] *Configurations include monitors.*

In order to make fair price comparisons among PS/2, PC-family, and competitive systems, like configurations were assembled. Added to base system prices were the following components: adaptable-sync color monitor, $570; 256KB EGA-equivalent board, $340; 512KB memory board with port, $450.

the way in which the pixels are produced account for their differences. Each produces 256 colors from a palette of more than 256,000 colors at a resolution of 720-by-400 in text mode and 640-by-480 in graphics mode. The 8513 produces pixels from a triangle of three dots; in the 8512 the pixel is made up of three slots side by side. (See "Synchronizing Graphics Standards," John C. Blair, Jr., May 1987, p. 150 regarding these technologies.)

The most popular monitor in the marketplace so far is the smaller of the two, the 12-inch 8513. Because it is smaller, images appear sharper on the screen, although they also appear to be slightly smaller than on the 8512.

Available as of July is the PS/2 Display Adapter, a $595 product that can be used in the Model 30 to provide 16 colors in 640-by-480 graphics mode or in the PC family systems to support the 8512 display. The PS/2 Display Adapter 8514/A, which must be used with a memory expansion kit, boosts Models 50, 60, or 80 to 256 colors and enhances performance in graphics mode. On the 8503 it displays up to 64 shades of gray at one time.

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	SI	Sieve MS C (sec)	Shuttle Regen (sec)	Price
PC	1.0	5.88	100 (12)*	–
9 MHz FastCACHE-286	7.1	1.32	28 (7)*	$399
12 MHz FastCACHE-286	10.3	.93	22 (6)*	$599

*Times in parentheses are with an 8087 or 80287.

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MARKET CONTEXT

DISKETTE DILEMMA

Considered in the long term, the new 3.5-inch diskette standard is clearly a solution and not a problem, but the new standard creates problems in hybrid sites. One high-volume dealer stated categorically that everyone who has bought a PS/2 system has also bought an external 5.25-inch diskette drive. IBM's offerings are these: 3.5-inch external drive, $395; 3.5-inch internal drive, $170; 5.25-inch external diskette drive, $335 plus $60 for an adapter. For environments that include members of both generations, the 3.5-inch drives would be used with AT machines; the 5.25-inch drives with PS/2 machines. The $33 IBM Data Migration Facility uses an existing standard printer cable to transfer data from the old generation to the new.

Attitudes toward the new PS/2 machines vary widely. One dealer described typical customers as being in one of two camps. The first still demands the XT, although it is clearly a system of the past. The other camp understands that the PS/2 is the system of the future, and buys it without hesitation. The decision is most difficult, however, for corporate buyers with large installed bases of PC- or AT-generation systems.

Take, for example, a large company with an installed base of between five and ten thousand personal computers that run applications strategic to the company's business. The R&D department tested several PS/2 models and found them compatible with the older systems but lacking any significant improvement to performance—today. Price is also a factor. Many companies find it hard to argue with buying attractively priced compatibles like the AST Premium/286, which can run applications just as efficiently as would the PS/2 machines—today. New machines are ordered on a routine basis. Which ones should be selected?

There may not be a compelling strategic reason for moving applications to PS/2 machines now, but an important factor is missing in the present scenario: the new operating system. (A sidebar on its status appears within the article "Twilight of DOS," Julie Anderson, this issue, p. 180.) With a new operating system in place, the decision to buy the PS/2 family could become a strategic one, and price/performance comparisons to AT-generation machines will be as outmoded as, to borrow an earlier theme, comparing the price and performance of cars ten years ago to those of today.

TABLE 3: *PS/2 Pricing and Part Numbers*

PART NUMBER	PRODUCT	PRICE	DATE AVAILABLE
IBM PERSONAL SYSTEM/2			
8530002	Model 30-002	$1,695	Now
8530021	Model 30-021	2,295	Now
8550021	Model 50-021	3,595	Now
8560041	Model 60-041	5,295	Now
8560071	Model 60-071	6,295	Now
8580041	Model 80-041	6,995	Now
8580071	Model 80-071	8,495	Now
8580111	Model 80-111	10,995	4th quarter '87
IBM PERSONAL SYSTEM/2 DISPLAYS			
8503001	12-inch Monochrome 8503	250	Now
8512001	14-inch Color-8512	595	Now
8513001	12-inch Color-8513	685	Now
8514001	16-inch Color-8514	1,550	Now
IBM OPERATING SYSTEM/2			
6280196	Standard Edition 1.0, 3.5-inch	325	1st quarter '88
6280201	Standard Edition 1.0 Technical Reference, 3.5-inch	200	1st quarter '88
6280200	Standard Edition 1.0 Toolkit	750	1st quarter '88
6280194	Standard Edition 1.1, 3.5-inch	325	TBA
6280212	Standard Edition 1.1 Technical Reference, 3.5-inch	200	TBA
6280211	Standard Edition 1.1 Toolkit	750	TBA
90X7900	Extended Edition 1.1, 3.5-inch	795	TBA
6280207	IBM COBOL/2	900	1st quarter '88
6280185	IBM FORTRAN/2	595	1st quarter '88
6280187	IBM C/2	525	1st quarter '88
6280179	IBM BASIC Compiler/2	595	1st quarter '88
6280183	IBM PASCAL Compiler/2	595	1st quarter '88
6280181	IBM Macro Assembler/2	225	1st quarter '88
IBM OPTIONS AND ADAPTERS			
1501215	Color Display Stand for 8512 Monitor	35	Now
1887972	Display Adapter 8514/A	1,290	Now
1887744	VGA Display Adapter for PC Bus	595	Now
6450353	1.44MB Diskette Drive	245	3rd quarter '87
6450354	44MB Fixed Disk Drive	1,395	3rd quarter '87
6450355	70MB Fixed Disk Drive	2,395	3rd quarter '87
6450377	115MB Fixed Disk Drive	3,495	4th quarter '87
1887989	8514 Memory Expansion Kit	270	Now
6450344	80286 Memory Expansion Option	549	Now
6450345	80286 Memory Expansion Kit	165	Now
6450367	80386 Memory Expansion Option	1,595	Now
6450372	80386 Memory Expansion Kit	1,295	Now
2685193	2MB Expanded Memory Adapter	1,295	Now
1497252	80286 Expanded Memory Adapter/A	1,045	4th quarter '87
6450375	PS/2 System Board Memory Expansion Kit	695	Now
6450379	PS/2 System Board 2MB Memory Expansion Kit	1,295	4th quarter '87
1501217	8087 Math Coprocessor	310	Now
6450356	80287 Math Coprocessor	525	Now
6450369	80387 Math Coprocessor (16 MHz)	795	3rd quarter '87
6450378	80387 Math Coprocessor (20 MHz)	1,195	TBA
6450348	Multi-Protocol Adapter/A	295	Now
6450347	Dual Asynchronous Adapter/A	210	Now
6450349	300/1200 Internal Modem/A	395	Now
83X9670	3278/79 Emulation Adapter	595	Now
4869001	5.25-inch External 360KB Diskette Drive	335	Now
6450244	5.25-inch External Diskette Drive Adapter	60	Now
1501216	Speech Adapter	345	Now
6450350	PS/2 Mouse	95	Now
1501224	Data Migration Facility	33	Now
81X8630	Music Feature	495	Now
3363-A11	Micro Channel Optical Disk Drive	2,950	3rd quarter '87
3363-A01	PC Bus Optical Disk Drive	2,950	Now
IBM PRINTERS			
4201002	Proprinter II	549	Now
4207001	Proprinter X24	799	Now
4208001	Proprinter XL24	1,049	Now
4216020	Personal Pageprinter	2,199	3rd quarter '87
5202001	Quietwriter III Printer	1,699	Now
IBM PERSONAL SYSTEM/2 SOFTWARE			
6280060	DOS 3.3	120	Now
6280059	DOS 3.3 Technical Reference	85	Now
6024475	TopView 1.12	175	Now
6280203	Graphics Development Toolkit 1.2	495	Now

Continued on p. 164

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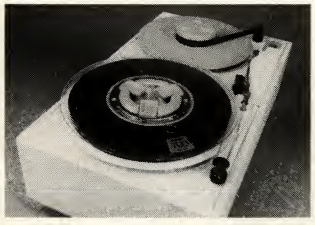
TABLE 3: *PS/2 Pricing and Part Numbers (continued)*

PART NUMBER	PRODUCT	PRICE	DATE AVAILABLE
*	Graphics Development Toolkit 2.0	$595	1st quarter '88
6024238	Fixed Disk Organizer	55	Now
6024401	Storyboard/2	350	Now
75X1121	DisplayWrite 4/2	495	1st quarter '88
74X9921	3270 Workstation Program 1.0	495	Now
75X1088	3270 Workstation Program 1.1	495	1st quarter '88
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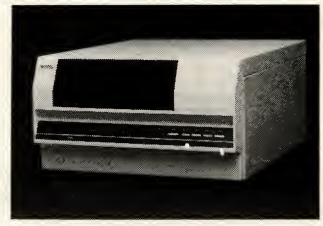
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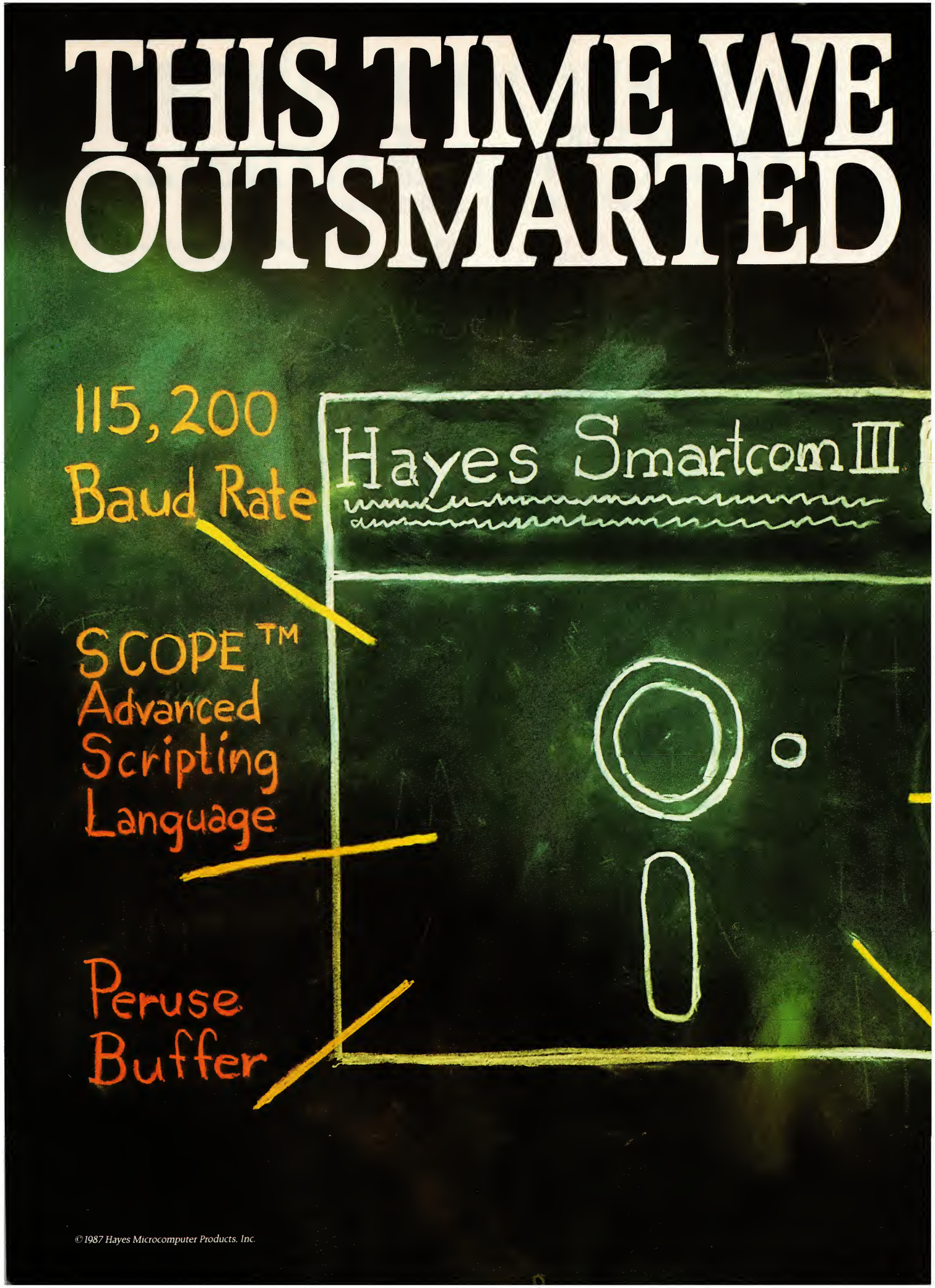
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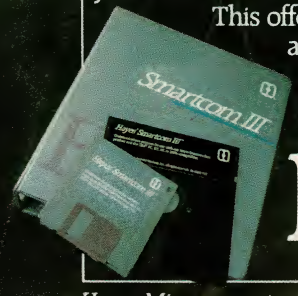
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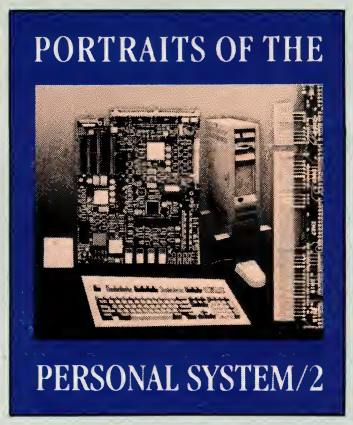
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The Cache Factor

Performance tests take a first look at how caching software affects speed in the PS/2s. Models 30, 50, and 60 are matched against the IBM XT and AT, the Compaq Deskpro 286, and the AST Premium/286.

MAXINE FONTANA

The inherent speed of the Personal System/2 family will not blow users away from their desktops as soon as they turn the system on. The machines' actual performance abilities are not immediately apparent. No one can categorically say that each PS/2 is *x* times faster than its predecessor. IBM has devised a performance "strategy" that involves the use of disk-caching software to nudge the speed upward for certain applications.

IBM has carefully documented PS/2 performance by commissioning the independent National Software Testing Laboratory (NSTL) to measure a variety of third-party software and establishing a range for each category of application. When tested by the NSTL, the Model 30 performed 1.3 times faster than the PC/XT in the worst case (processor-intensive CAD graphics) and 2.4 times faster in the best case (disk-intensive database applications). In the same tests, the Models 50 and 60 performed from 3.3 to 7 times faster than the XT. These tests, however, were conducted under controlled laboratory conditions; IBM makes no guarantee that users can duplicate these results.

The questions are: should we really discard our XTs and ATs in favor of the PS/2s to gain these favorable speeds? What can users expect from the new PS/2s in the way of performance—with and without caching software? To achieve a fair assessment in this article, class is pitted against class: the Model 30 is compared with the XT; and Models 50 and 60 with the AT, Compaq Deskpro 286, and AST Premium/286. (The Model 80 was not available for evaluation at the time this article was written.) Table 1 compares the performance and storage features of the tested machines.

The caching programs applied here are IBMCACHE, supplied with Models 50 and 60; the Compaq cache supplied with the Compaq Deskpro 286; and Super PC-Kwik, Multisoft's cache designed for a variety of machines. While not an exhaustive comparison nor a comprehensive analysis of caches, this is a first look at IBM's PS/2 performance strategy.

The Model 30, priced below the XT, is targeted at the XT market, but that is where the similarity ends; the Model 30 is a heavyweight compared with the XT. With a faster clock speed, faster effective transfer rate, lower interleave factor, zero wait states, and wider bus, it certainly can be expected to outperform the 4.8-MHz XT.

The 10-MHz Models 50 and 60 have a distinct advantage over the 8-MHz AT simply by having a faster



clock speed, faster effective transfer rate, and 1:1 interleaving. However, with an average seek time of 81.5 milliseconds (ms), the Model 50's disk speed is closer to the XT and the Model 30 than to the Model 60 and the AT. To boost performance, IBM provides disk-caching software as a standard feature of Models 50 and 60; the NSTL tested them with the disk-caching program, IBMCACHE, installed.

The Compaq Deskpro 286 has a faster clock (12 MHz) than Models 50 and 60, a faster disk (27.4 ms versus 36.6 ms for the Model 60), and a caching program. The AST Premium/286 has a 10-MHz clock, faster disk (29.4 ms), and zero wait states.

Of all data-processing tasks, the most costly in time is disk access. Regardless of clock speed, disk speed profoundly affects total processing time because of its mechanical nature. Before data are transmitted from disk to memory, two physical actions must be completed: the read/write head must move to the correct track, and the disk must rotate until it is positioned in the correct sector beneath the head. The faster the seek and rotation time, the faster the effective data access. Disk speed is an important factor when a large number of random reads are required, as in a database application.

One way to match the speed of processing to the speed of the disk is to adjust the interleave factor. The AT has an interleave factor of 3; once the head is positioned, three rotations of the disk are needed to read all sectors on the track. These rotations provide the time needed for the microprocessor or hard-disk adapter/channel to process a sector before the next sector is positioned under the head. (For a description of interleaving, see "Out from the Shadow of IBM . . . ," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52.)

The processing speeds of Models 50, 60, and 80 are fast enough to eliminate interleaving; each has an interleave factor of 1; once the head is positioned, only one rotation of the disk is needed to read all of the sectors on a track. This is a significant improvement over the AT; it is an even greater advantage if a block of sectors can be stored in RAM (in a cache, for example), because in a single seek and rotation, many sectors can become available to the application program.

CACHE FUNCTIONS

A disk cache, which is a collection in RAM of the sectors used most frequently by an application, significantly increases the performance of disk-intensive applications by decreasing the number of disk accesses. When a read is requested, not only is the sector containing the desired record read into the cache, but also a number of sectors following it on the track.

Depending on the implementation, the user can select a maximum of 2 to 17 sectors. In order to minimize track-to-track head motion, a well-designed caching algorithm adjusts the number of sectors read at each request, reading in either the maximum number or the remaining sectors to the end of the track, whichever is less. When another read is issued, the cache is searched first; if the data are found in the cache, the disk is not accessed.

One function of a cache is anticipatory—to store in RAM the data that are most likely to be used in the near future. For example, in a program performing sequential reads, several sequential records are placed in the cache in one disk access, thereby decreasing the total number of accesses needed to read in the entire file.

Another function of a cache is to store in RAM the data used most frequently—for example, an index to a database file. In an ideal situation, the index would be read from disk into the cache at the beginning of a database session and would remain there

ILLUSTRATION • JANE STERRETT

TABLE 1: *Storage and Performance Features*

	PC/XT	MODEL 30	PC/AT	MODEL 50	MODEL 60	DESKPRO 286	PREMIUM/286
Microprocessor	8088	8086	80286	80286	80286	80286	80286
Clock speed (MHz)	4.77	8.0	8.0	10.0	10.0	12.0	10.0
Wait states	0	0	1	1	1	1	0
Interleave factor	6	3	3	1	1	2	2
Bus width (bits)	8	16	16	16	16	16	16
Track-to-track seek time (ms)	18.0	16.7	6.0	16.6	5.9	4.1	4.9
Average seek time (ms)	84.2	83.5	37.1	81.5	36.6	27.4	29.4
Effective transfer rate (KB/sec)[a]	84.8	127.5	170.1	255.0	255.0	255.0	255.0
Memory	640KB	640KB	640KB	1MB	1MB	640KB	640KB
Disk capacity (MB)	20	20	30	20	30	40	40
Vendor-supplied cache	No	No	No	Yes	Yes	Yes	No

[a] *On machines with caching, the effective transfer rate is measured with the cache turned off.*

The XT and AT fall behind their newer competitors in clock speed, interleaving, and effective transfer rate. In disk speed, the XT, Model 30, and Model 50 are comparable as are the AT and Model 60; however, the Compaq and AST disks are faster.

throughout the session; no seek or rotation time would be lost rereading the index every time it is needed.

When the cache eventually fills up, a cache-management algorithm must decide which sectors should be replaced in the cache. Algorithms used to manage paging in large virtual memory machines, such as the least-recently-used and least-frequently-used algorithms, can be adapted for cache management. The actual programming methods used to search the cache for the requested sector and to determine which sector has been accessed least frequently ultimately determine how well the cache functions.

A cache performs a function similar to that of the file buffers created by using the BUFFERS command in the CONFIG.SYS file. Both are meant to hold data in RAM so that it can be reused without rereading the disk. The buffers contain only the sectors that have been specifically requested, however, while the cache also contains sectors that have been read in anticipation of their being used at some later time. The capacity of the buffers is also less than that of a typical cache. Even using the maximum of 99 buffers, only 49.5KB of data can be stored. In addition, the DOS *Reference* warns that performance often decreases as more buffers are used because of the time needed to search and maintain the buffers and the reduced memory available to the application.

With a cache, the user can select how much RAM to dedicate to sector storage. As with buffers, the method of selection is empirical; the optimal cache size varies from application to application. Although performance eventually deteriorates if the application has too little memory for data, a cache (unlike a buffer) is not restricted to conventional memory—it also can reside in extended memory. The disadvantage of using extended memory is that transfer to and from the cache must be done in protected mode with real-mode hardware interrupts disabled. This could result in a loss of characters during high-speed, interrupt-driven data transmission.

In theory, a cache can improve the write performance of a system by collecting sectors in RAM for batch writing, say a track at a time. This is seldom practical because of the danger of losing unwritten data in a power failure or other system interruption. The most common type of cache performs *write-through*, meaning that all output sectors are immediately written to the disk, but through the cache—that is, a copy of each sector written to the disk also is placed in the cache in case it needs to be read back in later.

ANALYZING PERFORMANCE

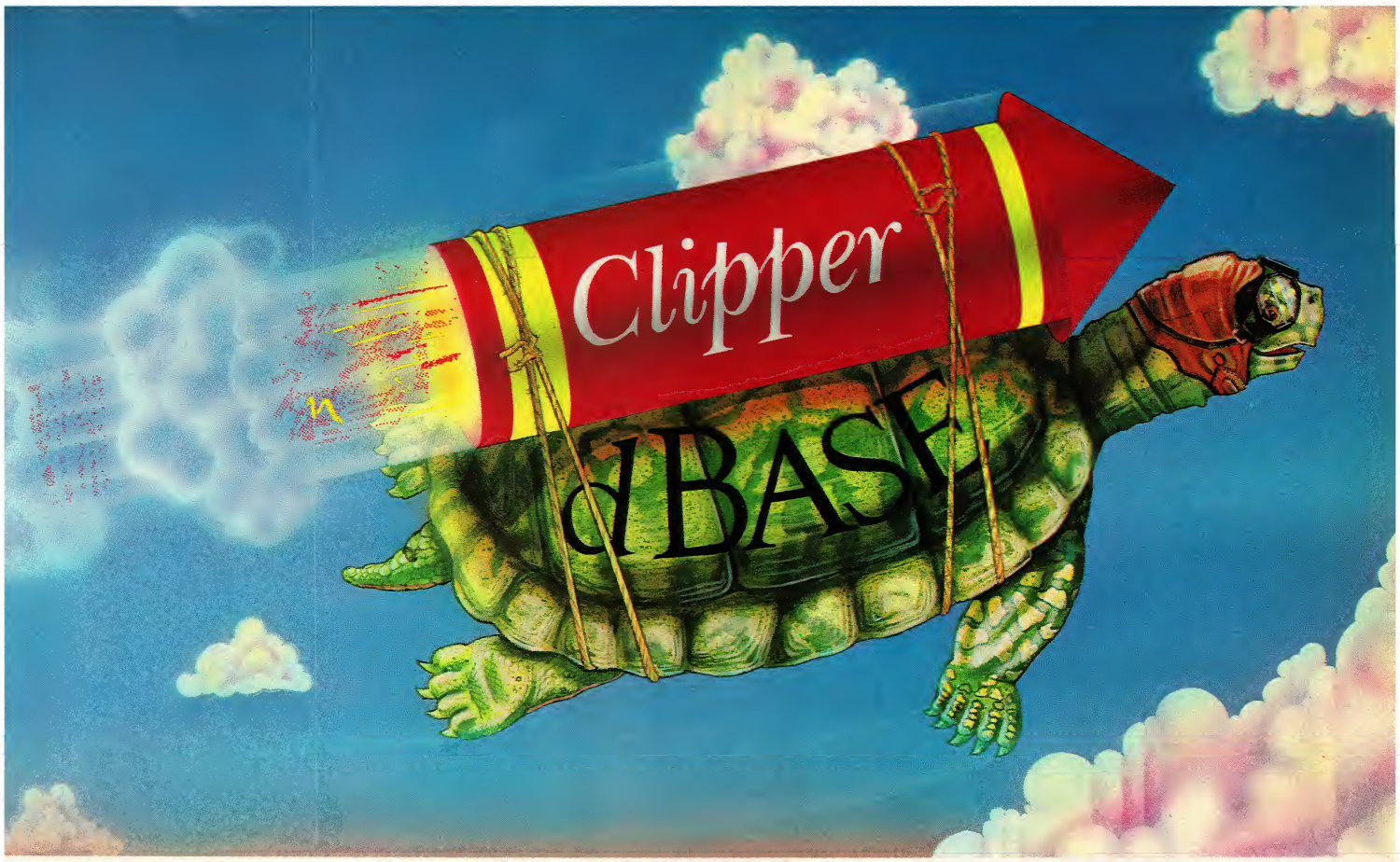
Three products were tested to determine the benefits of caching on PS/2 and earlier machines: the IBMCACHE program provided with Models 50, 60, and 80; the CACHE program available from Compaq for its Deskpro machines, and Super PC-Kwik, a separate utility from Multisoft Corporation. All of these were tested in several disk-intensive procedures, including three database benchmarks, and a compile and link of a C program.

IBMCACHE, a write-through cache managed by a least-recently-used algorithm, is distributed as a hidden file on the Models 50, 60, and 80 Reference Diskettes. For first-time installation, the Reference Diskette is placed in drive A: and the command A:IBMCACHE is entered. A menu presents options to install the cache, view its parameters, modify the parameters, or delete (uninstall) the cache.

The default parameters are 64KB in low (conventional) memory with a page size (maximum number of sectors read in at once) of four sectors. With the modify option, the user can set cache size to a value between 16KB and 512KB in low memory or 16KB and 15MB in extended memory; page size can be two, four, or eight sectors.

The install procedure creates an IBMCACHE.SYS file on the hard disk and adds a DEVICE statement, which contains the sizing parameters, to the CONFIG.SYS file. Thereafter, each time the system is reset, the cache is activated. The user can change cache parameters by rerunning the install procedure or modifying the CONFIG.SYS file with an editor. The meanings of the parameters on the DEVICE line are explained in the documentation.

The Compaq CACHE program is included on a supplemental User Programs diskette supplied with all Compaq 80286 and 80386 models. Installation is done either by executing the INSTALL program or by copying files to the hard disk and then modifying the CONFIG.SYS file. The INSTALL program presents a menu similar to the one in IBMCACHE, with options to install or uninstall the cache and display or set the parameters. Cache size can be between 128KB and 2MB and can be



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located either in conventional or extended memory. The default size is 256KB in conventional memory.

Super PC-Kwik by Multisoft is a caching program designed to run on a variety of computers. For a full description of its characteristics, including installation procedures, parameters and defaults, see "Super PC-Kwik," Product Watch, Ted Mirecki, this issue, p. 211.

Benchmarks were run three ways: without a cache, with a cache provided by the vendor, and with Super PC-Kwik. For the tests using a vendor cache, IBMCACHE was used for all IBM machines and the AST Premium/286, while the Compaq cache was used on the Deskpro 286.

With each cache, an attempt was made to optimize parameters for best performance. For database applications, a cache size of 256KB and page size of eight sectors were found to be optimal in most cases. A cache of this size is practical on machines with extended memory, but could cause problems in large applications running on machines with no more than 640KB of memory. According to IBM, this is the reason that a cache was not made available for the XT, AT, and Model 30. As shown by the results obtained here, however, even these machines can benefit from a cache when running disk-intensive applications with limited memory. On machines with extended memory, however, the performance in database applications did not differ significantly with the cache in either conventional or extended memory.

For the C compilation, IBMCACHE performed best at 256KB with a page size of four sectors, while Super PC-Kwik was optimal at 256KB, a page size of eight sectors, and operating out of extended memory.

Database benchmarks. Because database applications are particularly disk intensive, several benchmarks were performed using dBASE III PLUS from Ashton-Tate. The first benchmark sorted a 331KB file (600 565-byte records). Although best results are achieved when an entire file can be read into the cache at one time, a file slightly larger than the cache was used to approximate a real-world application more closely. Regardless of the sorting algorithm, sorts are always disk intensive when the file size exceeds available memory. A cache is expected to increase performance by storing some portion of the file in RAM, thus reducing disk access whenever the next portion of the file is in the cache.

In addition, five *PC Tech Journal* data-management benchmarks were run. Three of the benchmarks ran too fast to demonstrate significant performance differences. The other two involve both sequential and random reads and writes and provide good real-world tests of the machines with and without caching. (For benchmark definitions, see "Evaluating Data Managers as Development Tools," Julie Anderson, August 1985, p. 46.)

One benchmark added 900 303-byte records to an empty file and indexed them. The benefit of caching was expected to be apparent because a single read would bring slightly more than 13 records into the cache, reducing the number of reads needed to read the entire file. The other benchmark tallied all records having a given value in a specific field. Because this benchmark involves both sequential and random reads and writes, caches were expected to enhance results.

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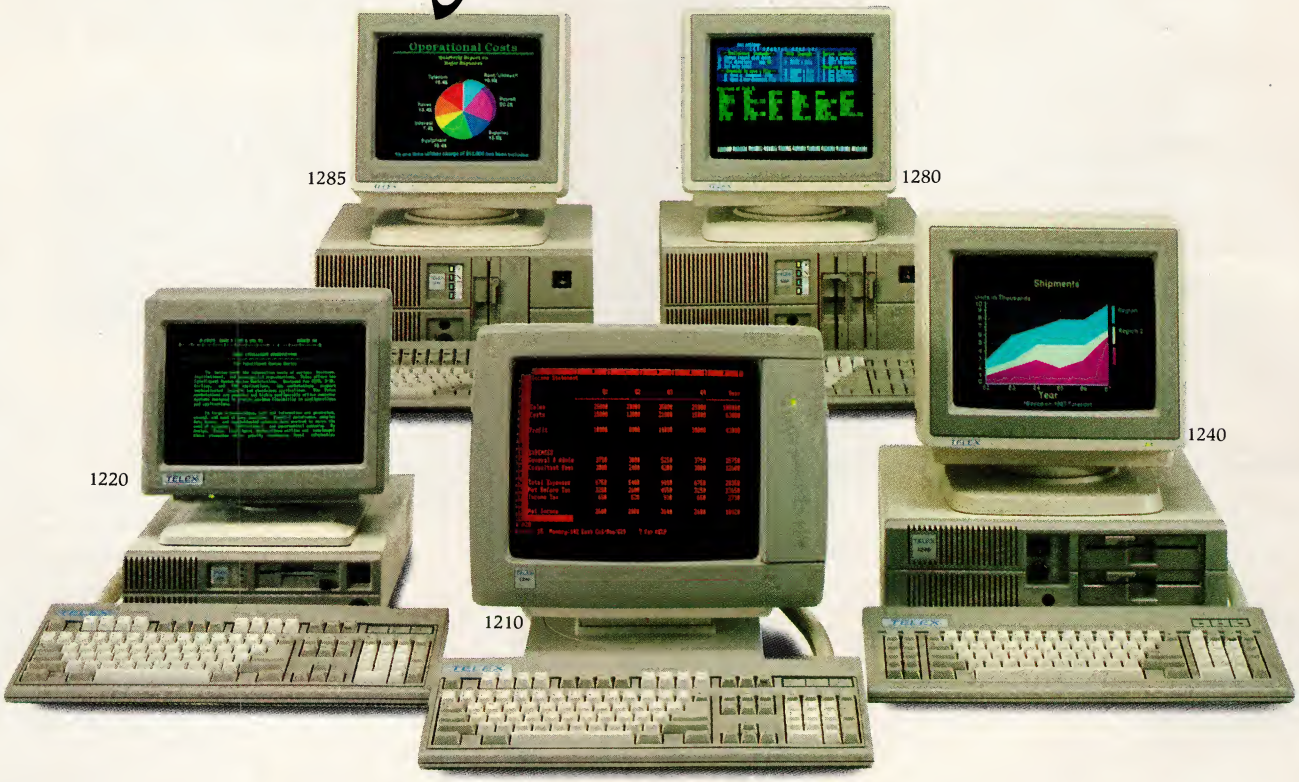
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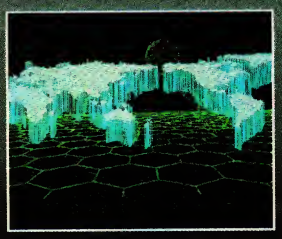
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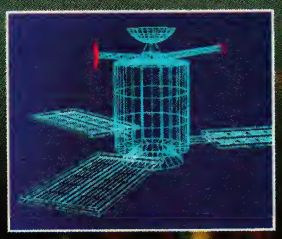
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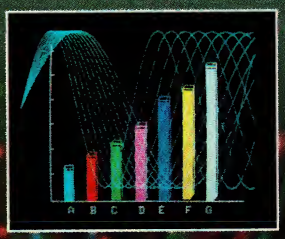
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where files are loaded and moved many times (the Microsoft compiler uses four passes), caching is expected to improve performance significantly. However, the computer with the best processor speed also is expected to perform well even without a cache.

CACHE COMPARISONS

As expected, the higher powered Model 30 outperformed the XT when no caching software was used on either machine. It sorted the 600-record file 1.33 times faster; read in and indexed the 900-record file 1.46 times faster; and, tallied the codes 1.14 times faster (see table 2).

With IBMCACHE installed on the Model 30, it completed the sort 2.17 times faster than the XT; read in and indexed 2.0 times faster; and tallied 2.07 times faster. Using IBMCACHE, the Model 30 can complete disk-intensive applications twice as fast as the XT. Even with IBMCACHE installed on the XT, the Model 30 is still the performance leader, completing the database benchmarks 1.74 times faster on the average. Similar performance upgrades are possible using Super PC-Kwik.

Comparing effective performances of the Models 50 and 60, AT, Compaq Deskpro 286, and AST Premium/286 is difficult because of the many ways to view results and draw conclusions. For example, the computers can be compared running as configured by their vendors—that is, with the IBM Models 50 and 60 using IBMCACHE, the Deskpro 286 using the Compaq cache, and the AT and Premium/286 using no cache—or they can be compared running at maximum speed, perhaps with a third-party cache. (For reviews of the Compaq and AST machines, see "Compaq Deskpro 286," Steven Armbrust and Ted Forgeron, August 1986, p. 80 and "Premium/286," Steven Armbrust and Ted Forgeron, June 1987, p. 74.)

TABLE 2: *Performance Results, Model 30*

	XT[a]	MODEL 30
SORT 600 RECORDS USING dBASE III PLUS		
No cache	128 (100)	96 (133)
IBMCACHE	100 (128)	59 (217)
Super PC-Kwik	110 (116)	66 (194)
APPEND AND INDEX 900 RECORDS		
No cache	124 (100)	85 (146)
IBMCACHE	107 (116)	62 (200)
Super PC-Kwik	109 (114)	63 (197)
DOCUMENT AND TALLY CODES FROM ONE COLUMN		
No cache	87 (100)	76 (114)
IBMCACHE	74 (118)	42 (207)
Super PC-Kwik	82 (106)	49 (178)

Times are given in seconds.

[a] *The XT used is the standard 4.77-MHz machine with 640KB conventional memory. It is considered the baseline machine, and its performance is normalized to 100. Numbers greater than 100 indicate the relative performance expressed as a percentage of the baseline machine.*

The Model 30 outperforms the XT in disk-intensive applications on an average of 1.3 times in the absence of caching software and 1.7 times with a cache installed.

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TABLE 3: *Performance Results, Models 50 and 60*

	AT[a]	MODEL 50	MODEL 60	DESKPRO 286	PREMIUM/286
SORT 600 RECORDS USING dBASE III PLUS					
No cache	64 (100)	84 (76)	56 (114)	55 (116)	54 (118)
Cache[b]	45 (142)	47 (136)	36 (178)	35 (183)	36 (178)
Super PC-Kwik	28 (228)	26 (246)	22 (291)	20 (320)	20 (320)
APPEND AND INDEX 900 RECORDS					
No cache	38 (100)	60 (63)	36 (105)	29 (131)	29 (131)
Cache[b]	34 (112)	28 (136)	25 (152)	25 (152)	23 (165)
Super PC-Kwik	20 (190)	22 (173)	20 (190)	17 (224)	15 (253)
DOCUMENT AND TALLY CODES FROM ONE COLUMN					
No cache	38 (100)	60 (63)	34 (112)	31 (122)	31 (122)
Cache[b]	18 (211)	25 (152)	18 (211)	24 (158)	16 (238)
Super PC-Kwik	28 (136)	30 (127)	21 (181)	20 (190)	19 (200)
C COMPILE AND LINK					
No cache	197 (100)	146 (135)	143 (138)	113 (174)	106 (186)
Cache[b]	156 (126)	131 (150)	114 (173)	115 (171)	99 (199)
Super PC-Kwik	153 (129)	130 (152)	123 (160)	110 (179)	99 (199)

Times are given in seconds.

[a] *The IBM PC/AT is considered the baseline machine and its performance is normalized to 100. Numbers greater than 100 indicate the relative performance expressed as a percentage over the baseline machine. The AT used has an Above Board PS/AT and piggyback card and is configured for 640KB conventional memory and 3,072KB extended memory.*

[b] *This is the IBMCACHE for all IBM machines and the AST Premium/286, and the Compaq cache for the Compaq Deskpro 286.*

Without a disk cache, the Model 60, Compaq Deskpro 286, and AST Premium/286 outperform the AT in disk-intensive database applications. The Model 50 lags way behind. With caching software, the Model 50 can compete effectively with the AT. When processor performance is important, the Model 50 not only surpasses the AT, but also approaches the Model 60.

To simulate a user's approach to this kind of problem, each computer was tested under several conditions: with no cache running; with the vendor-supplied cache running; and, with a third-party cache installed. Each was compared with a baseline machine: the AT as supplied, with no cache.

In the benchmark using dBASE III PLUS to sort a 600-record file, the Model 60, Deskpro 286, and Premium/286 all performed at about the same level: without caching software, they completed the sort from 1.14 to 1.18 times faster than the AT; with cache, they were 1.83 times faster than the AT (see table 3 and figure 1). These results were expected and certainly indicate the tough competition among the Model 60, Deskpro 286, and Premium/286 for top-performance honors.

The most surprising sort results came from the Model 50. With a disk speed about half that of the AT, the Model 50 was expected to perform more slowly without a cache, and indeed it did, completing only 76 percent of the sort in the time the AT took to finish the same sort; however, with IBMCACHE installed, the Model 50 performed 1.36 times faster than did the AT with no cache. Even with Super PC-Kwik installed on both machines, the Model 50 surpassed the AT, completing the sort 1.08 times faster.

These results illustrate the significant impact of a cache in compensating for a slow disk. Although the Model 50's architecture should make it a better performer than the AT, its slower disk holds it back despite the interleave factor of 1; once its disk speed is overcome by decreasing disk accesses, its performance surpasses the AT as supplied. Obviously, IBM's distribution of caching software with the Model 50 is an important marketing strategy. The cache brings performance above the level of the AT—or to the AT's level with a cache installed in the AT.

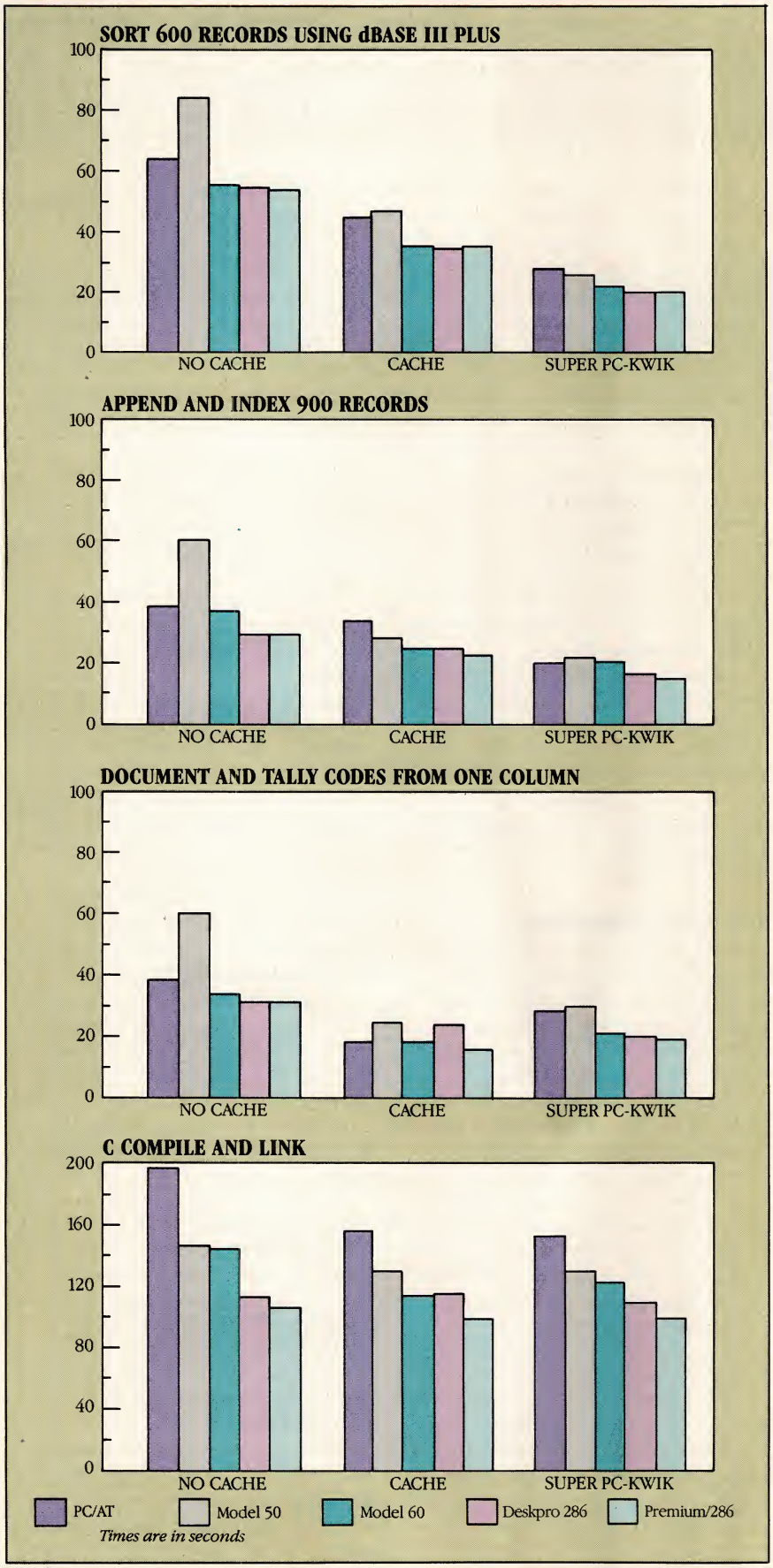
Importantly, performances of all the computers improved even more with Super PC-Kwik. The leading performers—the Premium/286 and Deskpro 286—completed the sort 3.2 times faster than the AT, followed closely by the Model 60 (2.9 times faster) and the Model 50 (2.46 times faster). When the AT was run with Super PC-Kwik, it improved its performance by 2.28 times, bringing it close to the level of the Model 50 running Super PC-Kwik.

When these computers were compared in their factory configurations, the Model 50 with IBMCACHE was 1.36 times faster than the AT, supplied without a cache; the Model 60 with IBMCACHE and the Deskpro with its cache were 1.5 times faster than the Premium/286 without cache, and 1.78 times faster than the AT. However, with Super PC-Kwik installed, the AT ran 1.29 times faster and the Premium/286 1.8 times faster than either the Model 60 or Deskpro 286, each running the vendor's caching software.

In the benchmark appending and indexing a 900-record file, results were very similar to those for the sort test. Without caches, the Deskpro and Premium/286, with their faster disks, were the definitive winners—1.31 times faster than the AT. The Model 60 was only 1.05 times faster than the AT; and, once again, the Model 50 lagged way behind. As expected in a disk-intensive test, the results mirrored the computers' disk speeds. Using the vendor-supplied caches across the board, the Premium/286 still remained ahead but by only a small margin—1.65 times faster than the AT. The Model 60 and Deskpro 286 tied for second place, completing the append-and-index test 1.52 times faster than the AT; and the Model 50 was 1.36 faster than the AT.

These results are not surprising. While the AST and Compaq machines have faster disks than the Model 60, the interleave factor of 2 costs them an extra rotation per read. The Premium/286, with zero wait states, has an edge over its two competitors. The Model 50 and AT also perform predictably. With cache installed on the Model 50, eight

FIGURE 1: *Performance Comparison, Models 50 and 60*



Disk caching can significantly improve performance in disk-intensive applications.

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TABLE 4: *Effect of Cache on Performance*

	AT	MODEL 50	MODEL 60	DESKPRO 286	PREMIUM/286
EFFECT OF CACHE ON SORT					
No cache	64 (100)	84 (100)	56 (100)	55 (100)	54 (100)
Cache (vendor)	45 (142)	47 (179)	36 (157)	35 (157)	36 (100)
Super PC-Kwik	28 (228)	26 (323)	22 (254)	20 (275)	20 (270)
EFFECT OF CACHE ON APPEND AND INDEX					
No cache	38 (100)	60 (100)	36 (100)	29 (100)	29 (100)
Cache (vendor)	34 (112)	28 (214)	25 (144)	25 (116)	23 (126)
Super PC-Kwik	20 (190)	22 (272)	20 (180)	17 (170)	15 (193)
EFFECT OF CACHE ON C COMPILE AND LINK					
No cache	197 (100)	146 (100)	143 (100)	113 (100)	106 (100)
Cache (vendor)	156 (126)	131 (112)	114 (124)	115 (98)	99 (106)
Super PC-Kwik	153 (129)	130 (113)	123 (116)	110 (103)	99 (106)

The Model 50, with the IBMCACHE installed, increases performance an average of threefold on the sort and append-and-index benchmarks; the others increase from 1.7 to 2.75 times. Caching effects decrease as processor performance gains importance.

sectors are read into RAM with each seek and rotation (due to the interleave factor of 1), while the AT with an interleave factor of 3 and no cache has considerable disk overhead.

However, when Super PC-Kwik was added to the AT, it beat not only the Models 50 and 60, but also the Deskpro 286 (each running with vendor caching software)—the AT ran from 1.25 to 1.4 times faster. When Super PC-Kwik was added to the Premium/286, it again took the top honors, running 2.53 times faster than the baseline AT. Thus, in database applications, computers distributed without cache can be made to outperform those running with vendor-supplied caches by installing a third-party cache. To be fair, all computers were allowed to run Super PC-Kwik. The Premium/286 remained the leader followed by the Deskpro 286, the Model 60 and the AT (tied!), and finally by the Model 50.

In the benchmark in which all records having a given value in a selected field were tallied, without caching, results were similar to those for the sort test; with vendor-supplied caches, results were spurious (table 3 and figure 1). Again, the Premium/286 led the field, this time followed closely by the Model 60. With Super PC-Kwik installed across the board, the results closely mirrored those for the append-and-index test.

In the last performance measure, the C compile and link, the Premium/286 running with Super PC-Kwik again led in performance. In this test, the effect of the cache is less pronounced because of the processing needed in addition to the disk accesses. Here, the benefits of zero wait states and faster clock speed proved extremely important: even without caching software, the Premium/286 completed the compile and link 1.86 times faster than the AT; the Deskpro 286 was 1.74 times faster; the Model 60 was 1.38 times faster; and the Model 50, 1.35 times faster. The Model 50, with its increased processing speed, surpassed the AT.

With vendor-supplied caching software installed, the Premium/286 maintained its superior performance level, completing the test at almost twice the speed of the AT with the Deskpro 286 and Model 60 coming in 1.71–1.73 times faster than the AT, and the Model 50 outperforming the AT 1.5 times (see table 3 and figure 1).

THE CACHE ADVANTAGE

Caching software, like mainframe paging, can have a significant effect on performance; it can transform a machine that appears to lumber along (like the Model 50) into a reasonable competitor (see table 4). When disk accesses are intensive, the cache has a remarkable effect: with Super PC-Kwik installed, the AT performed the sort 2.28 times faster, the Model 60, 2.5 times faster, and the Premium/286, 2.7 times faster—and the Model 50 was an amazing 3.23 times faster than its speed without a cache. Notice that the slower the disk, the greater the benefit of caching because numerous (slow) disk accesses can be avoided by keeping frequently used data in RAM.

In the benchmark in which records are appended to a file and reads are sequential rather than random, the cache again increased speed significantly by reading-in a block of records at one time. The Model 50 benefitted the most, completing the append 2.72 times faster than without a cache; all others were from 1.7 to 1.93 times faster. In the C compile and link, the effects of the cache were less because speed was determined to a large extent by processing time.

The test results confirm that caching software can increase the performance of any computer running disk-intensive programs. However, the size of the cache must be adjusted for the application. This is particularly true in computers with only 640KB of conventional memory because performance deteriorates by decreasing the memory available to the application; thus, IBM does not distribute its caching software with the Model 30. However, with memory expansion and third-party caches abundant—and with careful planning—the benefits of caching are available to any computer.

The tests also show that the Model 30 can definitely outperform the XT and is an important XT replacement machine. The distribution of caching software with Models 50 and 60 is also an excellent marketing strategy; the Model 50 running with IBMCACHE surpasses the performance of the AT without a cache and can definitely compete with—and sometimes surpass—the AT running without a cache. The Model 50 approaches (but does not equal in these tests) the performance level of the Model 60. Because two of the Model 60's leading competitors have faster disks, IBMCACHE helps to ensure that the Model 60 can remain in the same performance class.

Last but not least, these tests indicate that the AT is not yet obsolete. With third-party caching software added, it can compete favorably with Models 50 and 60 running IBMCACHE in disk-intensive applications.



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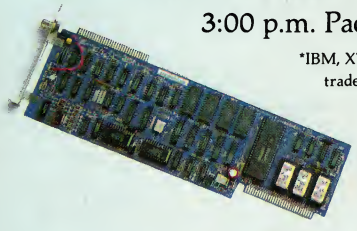
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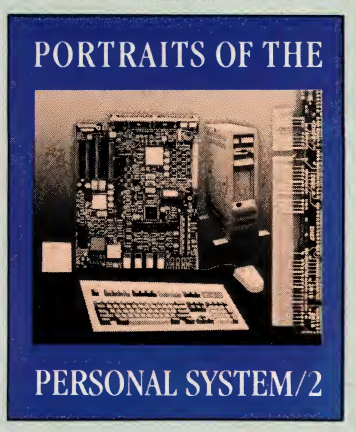
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Twilight of DOS

Athough it adds some new features, DOS 3.3—unable to provide the multitasking capabilities promised with OS/2—may be this aging operating system's swan song.

JULIE ANDERSON

Throughout its six years of life, DOS has operated on a variety of systems beginning with the 256KB double-diskette-drive PC and now stepping up to the new 80386-based Personal System/2 Model 80. To keep DOS virile, IBM added additional device support and features with each successive version. This method leaves IBM with a continuing problem: how to satisfy the power user's cravings without overwhelming the casual user with sophisticated, memory-monopolizing features.

IBM's approach is to offer the more complex features as optional memory-resident utilities so that DOS can be configured to each user's needs. Unlike most traditional minicomputer and mainframe systems, this configuration can be performed each time the system is booted or, in some cases, even while on-line.

DOS 3.3 was introduced to provide support for the IBM PS/2 family, but it actually runs on the entire line of IBM personal computers as well, including the PC, PC/XT, PC/AT, and PC Convertible. Although it is not the long-awaited multitasking operating system that can take advantage of the larger address space of the 80286 and 80386 processors, DOS 3.3 nevertheless has some new features that, if used carefully, are worthwhile. New and enhanced features introduced in DOS 3.3 are summarized in table 1.

Traditionally, existing programs run under each new version of DOS exactly as they did under the previous version, and DOS 3.3 is no exception. However, this also means that virtually no new or enhanced feature appears automatically; it must be requested by invoking a new DOS command or function call, adding a new parameter to an existing command or function call, or installing a memory-resident utility to DOS.

Although IBM has successfully maintained compatibility with previous DOS versions (as long as no new features are invoked), it has neglected to maintain internal compatibility—that is, the inability of some DOS features to work with each other. Some DOS commands are incompatible with others. For example, while SUBST is in effect, ASSIGN, BACKUP, DISKCOMP, DISKCOPY, FDISK, FORMAT, JOIN, LABEL, and RESTORE cannot be used, and CHDIR, MKDIR, RMDIR, and PATH must be, to quote from the *DOS 3.3 Reference* manual, "used with care." Inconsistencies in command syntax also have crept into DOS. Using PATH, JOIN, and SUBST with no arguments

displays the current settings, but using ASSIGN or PROMPT with no arguments resets the values. DOS 3.3 introduces additional incompatibilities and inconsistencies, discussed later.

As expected, DOS 3.3 adds support for the 1.44MB 3.5-inch diskette drives of the PS/2 family (DOS 3.2 already supported the 720KB diskette drive present in the Model 30) and the larger hard disks of the Models 60 and 80. FDISK now can be used on hard disks to create multiple DOS partitions. Device support also was added for two more asynchronous communications ports, COM3 and COM4. Speeds of up to 19.2 Kbps now may be set using the MODE command for any of the COM ports. In many cases, the choice "Fail" has been added as a possible option to the menu displayed when a critical error occurs. Fail means to return an error to the current DOS function call and then continue processing.

DOS 3.3 improves on many existing DOS commands. ATTRIB is enhanced to manipulate the read-only or archive attributes of all files in a directory and its subdirectories. BACKUP and RESTORE are more efficient and flexible; they now include options for automatically formatting backup diskettes and selectively restoring deleted files. Disk BASIC now EXECutes to BASICA and can perform all the commands previously limited only to BASICA. Neither version, however, supports the new video modes of the Video Graphics Array (VGA). The DATE and TIME commands now set the CMOS clocks of the AT and the PS/2 family. IBM also has enhanced its foreign-language support (see sidebar).

New DOS 3.3 commands include APPEND, which aids in locating files not in the current directory, and FASTOPEN, a filename cache. Batch files can now call other batch files, return, and continue processing. Two new DOS function calls flush a file's buffers without closing the file and increase the number of file handles available to a process.

Even though it was released with the PC Convertible in December 1985, DOS 3.2 did not support the Convertible's LCD display or thermal printer. DOS 3.3 rectifies this omission by adding support for both. A parameter was added to the GRAPHICS command to reproduce a graphic image exactly as it appears on the Convertible's LCD display. Its thermal printer was added to the list of supported printers.

CONFIGURATION AND MEMORY

DOS 3.3, just as in previous versions, requires additional memory to run. IBMBIO.COM and IBMDOS.COM together have grown 7,413 bytes, and although COMMAND.COM has increased 1,516 bytes, 23KB of free memory is still all that is required to load a second copy of COMMAND.COM. DOS 3.3's memory requirement depends on the size of the environment and the number of optional memory-resident utilities selected. Even booting a minimal DOS 3.3 without a CONFIG.SYS or an AUTOEXEC.BAT file can require different amounts of memory from machine to machine because DOS now allocates a default number of buffers and stacks based on memory size, diskette capacity, and machine type. For machines with more than 128KB of RAM, the number of buffers (each using 528 bytes) defaults to 5; for more than 256KB, the default is 10; and for more than 512KB, the default is 15. In the rare instance where a machine does not meet any of these conditions yet has a diskette drive with a capacity larger than 360KB, the default number of buffers is 3.

Additionally, by default no stack support is installed for the PC, XT, and Portable PC; for any other machine, DOS 3.3 reserves nine 128-byte stack frames. The BUFFER= or STACKS= commands in the CONFIG.SYS file can override both of these parameters. DOS minimum memory requirements range from approximately 50KB on a PC with a hard disk to 55KB on the PS/2 Models 30 and 60, the AT Model 339, and the PC Convertible.

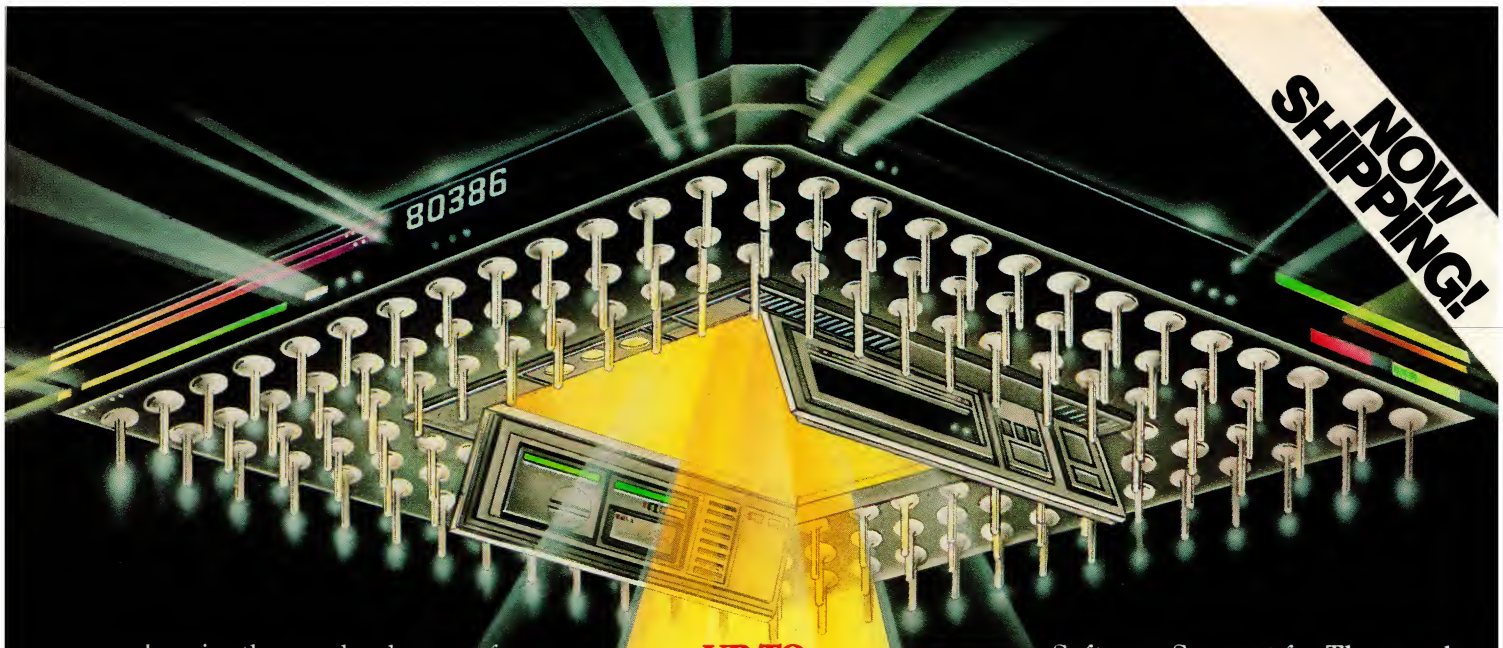
Of the several commands improved over earlier versions of DOS, most require adding a parameter at the command line. The improvements to MODE and ATTRIB, mentioned earlier, are straightforward, but the enhancements to BACKUP and RESTORE, DATE and TIME, FDISK, and FORMAT bear a closer look.



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BACKUP and RESTORE. With hard disks getting bigger, an efficient and flexible backup system becomes extremely important. DOS 3.3 significantly improves its BACKUP and RESTORE commands. The BACKUP command is more flexible with the /T parameter, which adds the capability to backup files modified after a certain time of day on the date specified through /D.

At long last, IBM also has added "automatic" formatting of backup diskettes —that is, if /F is



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CIRCLE NO. 169 ON READER SERVICE CARD

TABLE 1: *New and Enhanced Features of DOS 3.3*

CONFIGURATION COMMANDS		
BUFFERS	Enhanced	Default number tied to machine configuration
STACKS	Enhanced	Default number tied to machine configuration
DOS COMMANDS		
APPEND	New	Directory search path for files
ATTRIB	Enhanced	Subdirectories processed
BASIC	Enhanced	Compatible with BASICA
BACKUP	Enhanced	Performance improved
CALL	New	Batch file subcommand calls another batch file
COMMAND.COM	Enhanced	Fail option added to critical error processing message
DATE	Enhanced	Sets CMOS clock
FASTOPEN	New	Caches file location information
FDISK	New	Support added for multiple DOS partitions
FORMAT	Enhanced	Added support for 1.44MB drive
GRAPHICS	Enhanced	Convertible LCD and thermal-printer support
MODE	Enhanced	Support added for COM3 and COM4; speeds up to 19.2 Kbps
RESTORE	Enhanced	Performance and utility improved
TIME	Enhanced	Sets CMOS clock
DOS INTERRUPTS		
Multiplex (2FH)		
Append (B700H)	Enhanced	Gets installed state of APPEND
DOS function calls (21H)		
Set date (2DH)	Enhanced	Sets CMOS clock
Set time (2BH)	Enhanced	Sets CMOS clock
Set handle count (67H)	New	Sets number of handles per process
Commit file (68H)	New	Flushes file buffers

Some new features, such as support for multiple DOS volumes, improved BACKUP and RESTORE, and FASTOPEN, are welcome additions; others, such as APPEND and the DOS function call 67H (set handle count), must be used with extreme care.

specified, if FORMAT.COM can be found through the current path, and if the diskette matches the largest capacity of the drive. This is another example of IBM's obsession about compatibility with previous DOS versions; to take advantage of this new feature, the user must request it. With BACKUP, however, this degree of compatibility is inappropriate. Formatting during any backup procedure should *always* be automatic. Furthermore, BACKUP should format diskettes itself as needed, just as DISKCOPY does, without being instructed beforehand. Even as designed (with BACKUP EXECuting FORMAT.COM), BACKUP should make sure before beginning the backup that FORMAT.COM can be found. If not, this would give the user a chance to correct the situation before wasting time performing a backup that will abort as soon as the user runs out of formatted diskettes.

The most impressive feature of the BACKUP command is the new design of backup files. BACKUP now creates only two files on each diskette, CONTROL.xxx and BACKUP.xxx (where xxx is the diskette number—001 for the first diskette, 002 for the second, and so on). BACKUP gives the diskette an 11 character label, BACKUP xxx (the two spaces between BACKUP and xxx are part of the label).

CONTROL.xxx contains the names of the files that are on the diskette along with other useful control information such as file size, attribute, and date and time of creation. BACKUP.xxx contains the files themselves packed back to back. The size of BACKUP.xxx is the total number of bytes in each of the files backed up on that particular diskette. Besides using the diskette's space much more efficiently, this new backup design also saves time because only two file names need to be created on the diskette directory.

How much faster is the DOS 3.3 BACKUP command compared with DOS 3.2? A test was run to backup 649 files in 22 directories (13MB) onto freshly formatted 1.2MB diskettes using an AT Model 339. Times were measured with a stopwatch and did not include the time required to change diskettes. With DOS 3.2, the backup was performed in 25 minutes 32 seconds, but DOS 3.3 performed the same job in 16 minutes exactly—a 37-percent improvement. Furthermore, DOS 3.2 used 11 diskettes, but DOS 3.3 filled only 10 diskettes.

Because the user can no longer see which files are on each backup diskette, DOS 3.3 has the /L parameter that can be used to create a log file in which the time and date of the backup and the names of the files on each diskette are recorded. Unfortunately, errors that occur during the backup are not recorded. For example, with sharing loaded (via the SHARE command), if a file cannot be backed up because it is in use, DOS delivers to the screen the message "Not able to backup file." However, no error message is written in the log file, yet the file name is recorded in the backup log file. Similarly, when the backup is interrupted using Ctrl-Break, no indication is given in the log file that the backup aborted. After the backup is complete, the user should copy the log file from the source to another location so, if the source disk is damaged, the information in the log file can be used to help restore the files on the damaged disk.

IBM has attached numerous parameters to RESTORE in DOS 3.3 for added flexibility in selectively restoring files. The /B:*date* and /A:*date* parameters together with the /E:*time* and /L:*time* parameters can be used to restore files modified before or after a

certain date and earlier or later than a certain time. The /M parameter restores only the files that were modified or deleted since the backup was performed, and /N restores only the deleted files.

Even though the backup file formats have changed with DOS 3.3, RESTORE can retrieve files backed up with previous versions of DOS. However, RESTORE will no longer restore the three system files IBMBIO.COM, IBMDOS.COM, and COMMAND.COM. This is a reasonable change because these hidden files are difficult to delete unintentionally and do not change except with a new DOS version. If for some reason they need to be restored, the SYS command can be used. Furthermore, in the common case in which RESTORE is used to transfer files to a new computer or to upgrade to a new version of DOS, restoring the old system files is not desirable.

DATE and TIME. The ability to reset the CMOS clock from the command line in DOS is a welcome convenience, much easier than booting the AT diagnostic diskette and using the setup option. Of course, the system date and time must first be initialized through the setup option, but subsequently they can be changed through DOS 3.3's DATE and TIME commands. Because IBM did not introduce a clock until the AT, the addresses of third-party CMOS clocks have not been standardized. Therefore, the DATE and TIME commands have no effect on those multifunction boards using addresses for their CMOS clocks that are different from IBM's.

FDISK. With the need to support the 44MB and larger hard disks of the PS/2s, IBM ran up against its own DOS-imposed 32MB barrier. Instead of removing the 32MB limitation (as some third-party patches to DOS have done), IBM opted for multiple DOS partitions on hard disks. Of the four partitions allowed on a hard disk, two (at most) can belong to DOS. On a bootable disk—that is, the first hard disk in a system—a user can create both a *primary* and an *extended* DOS partition. A non-bootable disk accepts only an extended DOS partition.

The primary DOS partition is compatible with the DOS partitions created by previous DOS versions and is limited to a maximum size of 32MB. It corresponds to one logical disk drive and may or may not be bootable.

The non-bootable extended DOS partition can be as large as the drive itself and divided using FDISK into multiple logical drives, each of which is limited to a minimum size of 1 cylin-

CODE-PAGE SWITCHING

In August 1984, IBM introduced foreign-language support with DOS 3.0. This support consisted of 15 sets of date, time, numeric, and currency formats and six different keyboard layouts. The user selected the appropriate format set and keyboard layout at DOS boot-up time by including the COUNTRY command in the CONFIG.SYS file and loading the appropriate keyboard support program (such as KEYBFR.COM for France) in the AUTOEXEC.BAT file. The IBM Personal Computer Character Set—Code Page 437 (CP437)—was the only character set and it was missing many foreign-language characters.

This year, the International Standards Organization (ISO) sanctioned an 8-bit Multilingual Code Page, Standard DIS 8859. This character set contains letters from the alphabets of all Latin-based languages. IBM adapted this code page in EBCDIC for its mainframes, producing Multilingual Page 500 (MLP 500), which can be mapped directly to the ISO standard.

To support the industry standard on PCs and to facilitate transfer of data between IBM mainframes and PCs, IBM adapted an ASCII-based version of the multilingual code page and character set called the IBM Personal Computer Multilingual Code Page 850 (MLP CP850). This code page can be mapped directly to MLP 500 and to the ISO standard.

Unfortunately, MLP CP850 is somewhat different from CP437. Although the lower 128 characters have not changed, the mixed single- and double-line characters have been removed along with most letters of the Greek alphabet and some mathematical symbols. Replacing these characters in CP850 are the accented characters needed to support the Latin-based languages. Three other code pages supported by DOS 3.3 (which more closely resemble CP437 than CP850) are CP860 (Portuguese), CP863 (Canadian French), and CP865 (Norwegian and Danish). Together with CP850 and CP437, they allow DOS to increase its support to 11 languages in 19 countries.

Because the Multilingual Code Page offers substantial advantages in intersystem communication and expanded foreign-language support, embracing the new standard seems, in theory, the right move. In practice, however, moving to the new standard can involve both a big conversion effort as well as an awkward period when both the old and new standards must be supported.

Creating a new application using the Multilingual Code Page is straightforward. For most business applications that do not need the mathematical symbols or the Greek letters, it simply means avoiding the mixed single- and double-line graphics characters when designing screen forms and menu boxes.

Incompatibilities arise when converting an existing application from CP437 to CP850. When program text or data files created in CP437 are read with CP850, accented characters are displayed where boxes used to be. Similar problems surface when reading text or data files created under CP850 in CP437.

Two solutions are possible. First, when the switch to CP850 is made, a one-time conversion program can be run on the data files. This, of course, means that the application developer would need to provide this conversion program to users. The second approach allows coexistence of applications requiring different code pages. This is the solution that IBM provides with DOS 3.3. Called code-page switching, it allows the user to load the appropriate code page when an application is started.

A substantial portion of the changes made to DOS 3.2 to produce DOS 3.3 pertain to code-page switching. Yet, the DOS manual does a pathetic job of documenting it. Fortunately, IBM has a superior reference on code-page switching; it clearly states why code-page switching is necessary, what the programming considerations are in converting to the new multilingual code page, and how to live in harmony with it and the old CP437. This document is Volume 5, Number 6 of the *IBM Personal System/2 Seminar Proceedings* on application-development considerations of the Multilingual Code Page (IBM Publication Number G360-2758).

Code-page switching requires an EGA-compatible graphics subsystem (the PC Convertible LCD may also be used). Printers that support code-page switching include the IBM Proprinter Model 4201 and the IBM Quietwriter III Model 5202. The code pages for

TABLE: *Foreign-language Support in DOS 3.3*

CONFIGURATION COMMANDS		
COUNTRY	Enhanced	Specifies default code page and loads country information from the COUNTRY.SYS file
DEVICE = DISPLAY.SYS	New	Driver to provide code-page switching on display device
DEVICE = PRINTER.SYS	New	Driver to provide code-page switching for printers
DOS COMMANDS		
CHCP	New	Selects global code page
KEYB	New	Replaces ROM BIOS keyboard program to support code-page switching; reads keyboard definitions from KEYBOARD.SYS file
GRAFTABL	Enhanced	Displays foreign characters on CGA of code pages 437, 860, 863, or 865, but not 850
MODE	Enhanced	Supports the preparing, selecting, refreshing, and displaying status of code-page devices for display and printer
NLSFUNC	New	Supports extended country information and code-page switching via CHCP
DOS INTERRUPTS		
DOS function calls (interrupt 21H)		
General IOCTL (440CH)	Enhanced	Allows a device driver to prepare, select, refresh, and query code pages
Get extended country information (65H)	New	Returns information about the selected country formats, code pages, and conversion tables
Get/set global code page (66H)	New	Queries/Resets code-page defaults

Enhancements to DOS 3.3 support switching between the default code page and the new multilingual CP850. Code pages can be selected for the display, printer, and keyboard from the command line or from the application program interface.

each of these devices are defined in font files distributed on the DOS Startup diskette. These font files are identified by the extension .CPI (for Code Page Information).

Each country has two code pages: the MLP CP850; and either CP437 or one of the three mentioned above for French-speaking Canada, Portugal, or Denmark and Norway. The default code page is selected through the COUNTRY command in the CONFIG.SYS file. The user must prepare and select code pages for the display, printer, and keyboard.

Buffers for the display and printer code pages are reserved through the DEVICE=DISPLAY.SYS and DEVICE=PRINTER.SYS commands in the CONFIG.SYS file. For the display, the number of code pages to be supported are defined as well as the number of subfonts, usually one subfont for each font size. For each printer, both the code pages supported directly by the hardware and the number of additional code-page buffers that must be reserved are specified. Code pages for the display and printer devices are prepared through the MODE command, by identifying the .CPI file to be loaded into the reserved buffers. MODE is also used to select the code page to be activated, to refresh the active code page, and to display the active code page along with a list of currently available code pages.

Code-page support for the keyboard is installed by loading a keyboard program that replaces the ROM BIOS keyboard routine. The new KEYB command (used instead of the KEYBxx.COM files of previous DOS versions) reads the keyboard definitions from the KEYBOARD.SYS file and uses the information to convert scan codes to ASCII characters.

Finally, NLSFUNC, once loaded, allows code pages to be switched from the command line through the new command, CHCP.

Even with the code-page switching support from the operating system, developers must be warned that current applications may need to be modified in order to be compatible. Applications that use video interrupt 10H, keyboard interrupt 9H, or printer interrupts 5H or 17H may be incompatible with code-page fonts loaded by DOS. Additionally, applications that maintain their own text fonts in graphics modes must be aware of code-page switching and modify their fonts appropriately.

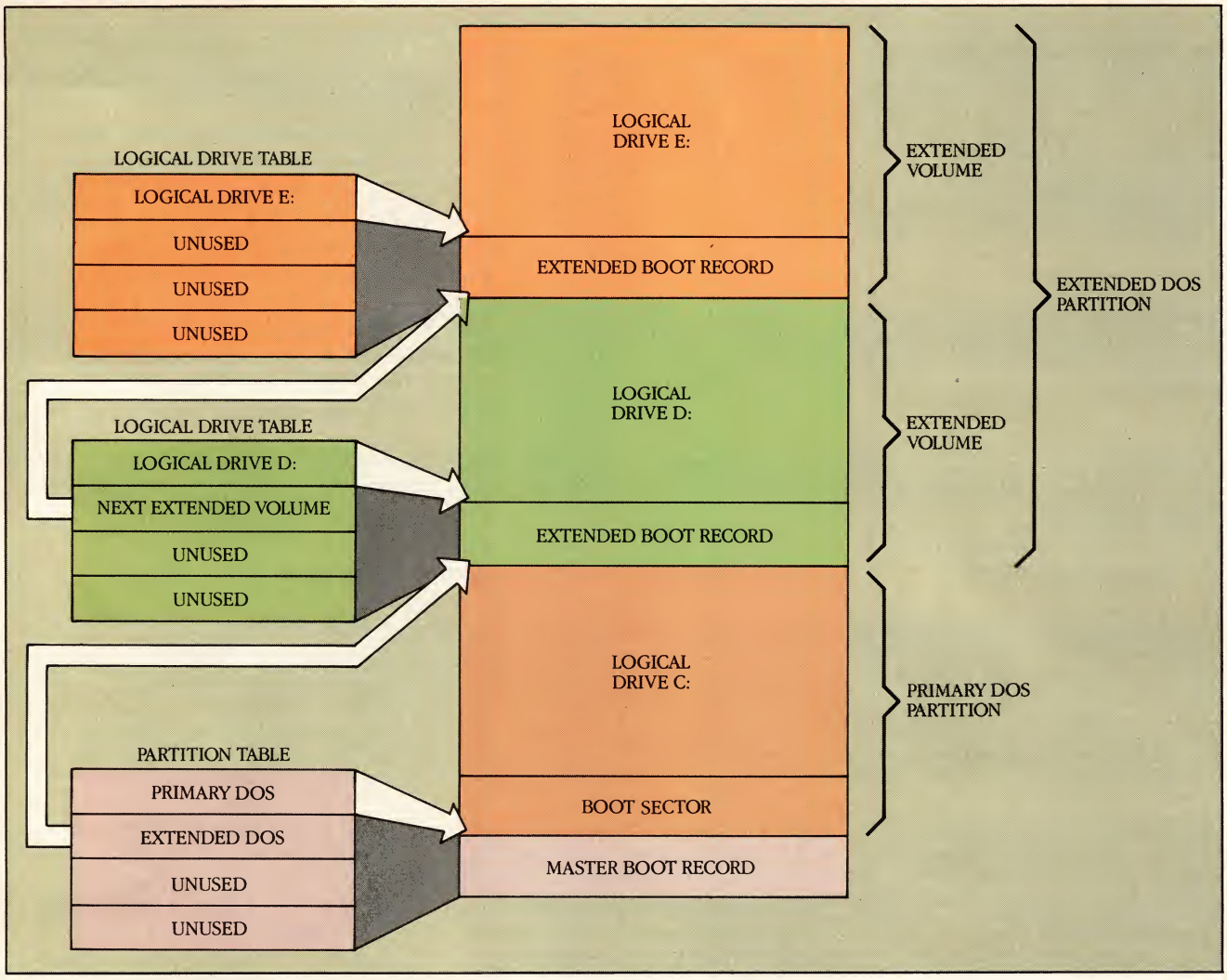
Two new interrupt 21H DOS function calls query the current state of code-page support and control code-page switching from an application. DOS function call 65H (get extended country information) returns information about the selected country formats and code page, including lower-to-uppercase and filename-character-conversion tables. DOS function call 66H (get/set global code page), returns the active and default code pages or resets the code pages of prepared devices to their defaults.

Device drivers may use a new generic IOCTL (I/O control) request (AX=440CH) function to implement code-page switching. This call can prepare, select, refresh, and query code pages. Any device supporting code-page switching can be handled through this function call.

Converting from CP437 to CP850 is a complex topic fraught with issues that may stymie the developer who is trying to deliver applications to users in foreign countries. *PC Tech Journal* plans to address these issues in depth in a forthcoming issue.

—JA

FIGURE 1: *Hard-disk Partitioning*



Two DOS partition types are now recognized. The primary DOS partition is compatible with previous DOS partitions, and a new extended DOS partition holds multiple *extended volumes*, each consists of an *extended boot record* and a *logical block device*. The extended DOS partition shown here is divided into two extended volumes with logical drives D: and E:.

der and a maximum size of 32MB. As many logical drives can be created as there are device specifiers (letters D to Z) available to name them.

The layout of a hard disk is shown in figure 1. Sector 1 on the first track (cylinder 0, head 0) is the master boot record. This holds the hard disk's partition table, which has an entry for each of the four possible partitions. The primary DOS partition is identified by a system indicator of 01H if a 12-bit file allocation table (FAT) is used or 04H if a 16-bit FAT is used. The extended DOS partition is identified by a system indicator byte of 05H. The remainder of the first track is reserved for disk type information.

An extended DOS partition is actually an assembly of *extended volumes*, each of which consists of an *extended boot record* and a *logical block device*. Similar to the master boot record, the extended boot record contains a logical drive table that describes the logical drive (its size and whether a 12-bit or 16-bit FAT is used) and points to the next extended volume. Each logical block device consists of a boot record and the logical drive. In figure 1, the extended DOS partition is divided into two extended volumes with logical drives D: and E:.

When partitioning the 44MB hard disk of the PS/2 Model 60, the user's first impulse might be to create a primary DOS partition (drive C:) with the maximum size of 32MB and then use the remaining 12MB to create an extended DOS partition containing one logical drive (drive D:). Unless large files force the 32MB size of the primary DOS partition, however, this may not be the most efficient use of space. The 12MB drive D: will use a 12-bit FAT with the space-wasting cluster size of 8 sectors (4,096 bytes). Contrary to the *DOS 3.3 Reference* manual's claim that a 16-bit FAT will be used (and, therefore, a 4-sector cluster size) when the number of sectors on a logical drive exceed 20,720 (10MB), FORMAT does not create a 16-bit FAT until the number of sectors in a logical disk exceeds the number that can be allocated using 4,092 8-sector clusters. (4,092 is the maximum cluster number that can be represented in a 12-bit FAT entry.) Because multiplying 8 sectors per cluster by 4,092 clusters yields 32,736 sectors of 512 bytes (.5KB each), the break-off point for a 16-bit FAT is 16MB.

To complicate matters further, FDISK accepts partition and logical drive sizes in numbers of cylinders, not in sectors or megabytes. To calculate

TABLE 2: *DOS 3.3 Diskette Format Structure*

	SECTORS PER TRACK	NUMBER OF TRACKS	TOTAL SECTORS	SECTORS PER CLUSTER	SECTORS PER FAT	SECTORS PER ROOT DIRECTORY	MAX. ENTRIES IN ROOT DIRECTORY
3.5-INCH DISKS							
High-density 1.44MB	18	80	2,880	1	9	14	224
Low-density 720KB	9	80	1,440	2	3	7	112
5.25-INCH DISKS							
High-density 1.2MB	15	80	2,400	1	7	14	224
Double-sided 360KB	9	40	720	2	2	7	112
Double-sided 320KB	8	40	640	2	1	7	112
Single-sided 180KB	9	40	360	1	2	4	64
Single-sided 160KB	8	40	320	1	1	4	64

DOS 3.3 supports these formatted structures for diskettes. The number of sectors per FAT for a 3.5-inch 720KB diskette is incorrectly given as 4 in the *DOS 3.2 Reference*. DOS 3.2 and 3.3 format 3 sectors per FAT for a 720KB diskette.

the minimum partition size that will force a 16-bit FAT, use this formula:

cyl = (max clusters * 8) / (heads * spt)

where **cyl** is the number of cylinders to give to FDISK, **max clusters** is 4,092, **heads** is the number of heads on the hard disk, and **spt** is the number of sectors per track. On the Model 60's 44MB disk, for example, the number of heads is 7 and the number of sectors per track is 17, so the minimum 16-bit FAT partition size is 275 cylinders.

FORMAT. This command automatically formats a diskette to the maximum capacity of the diskette drive. Smaller capacity diskettes can be formatted in larger capacity drives by specifying a parameter. For 360KB drives, /1 is used to format a single-sided diskette and /8 is used to format 8 sectors per track, instead of the usual nine. For 360KB diskettes in a 1.2MB drive, /4 is used to specify quad-density.

Confronting the problem of formatting 720KB diskettes in the 1.44MB PS/2 drives, IBM has introduced yet another way of specifying the capacity of diskettes. The new parameter pair /N: and /T: specify the number of sectors per track and the number of tracks respectively. To format a 720KB diskette in a 1.44MB drive, the parameter values to use are /N:9 and /T:80 (9 sectors per track and 80 tracks). Do not assume, however, that /N: and /T: can be used in place of (or even with) the previously defined FORMAT parameters. Both /N: and /T: are incompatible with /1 and /4; thus, they cannot be used to format single-sided diskettes.

The problem with these parameters is that the user must communicate with FORMAT only on FORMAT's terms. The nontechnical end user does not care how many sectors there are per track or how many tracks are on a diskette. What matters is total capacity. The parameter IBM should have added is one that specifies capacity, such as C=. For example, C=720 would format a 720KB diskette on a 3.5-inch 1.44MB drive. This parameter is more logical, less cumbersome, and could be used for other capacity diskettes as well (C=160, C=180, C=320, C=360).

Table 2 presents the formatted structure for all the diskette types that DOS 3.3 supports. The number of sectors per FAT for a 720KB diskette is incorrectly documented as 4 in the *DOS 3.2 Reference*. Both DOS 3.2 and DOS 3.3 format 3 sectors per FAT for a 720KB diskette. To aggravate these inconsistencies, the 3.5-inch 720KB diskettes that IBM delivers with DOS 3.3 and the *Technical Reference* are formatted with one sector per cluster—a format that cannot be duplicated with the FORMAT program as documented.

FILE-FINDING FEATURES

Since the creation of subdirectories, finding files that are not in the current directory requires major search-and-rescue missions. Two new commands in DOS 3.3—APPEND and FASTOPEN—are file-finding aids. APPEND looks for files not in the current directory, and FASTOPEN speeds up the search.

APPEND. By searching the path (created with the PATH command, which was introduced with version 2.0), DOS can find executable files and batch commands—that is, only files with extensions .EXE, .COM, or .BAT. Programs that need to find overlay files, drivers, or data files can also search the path, but DOS does not provide this service transparently. Many programs—especially compilers, editors, and data managers—solve this problem by specifying the location of the program's associated files through a user-defined environment parameter. Other programs, such as WordPerfect 4.2, make specifying the location of associated files part of the installation process.

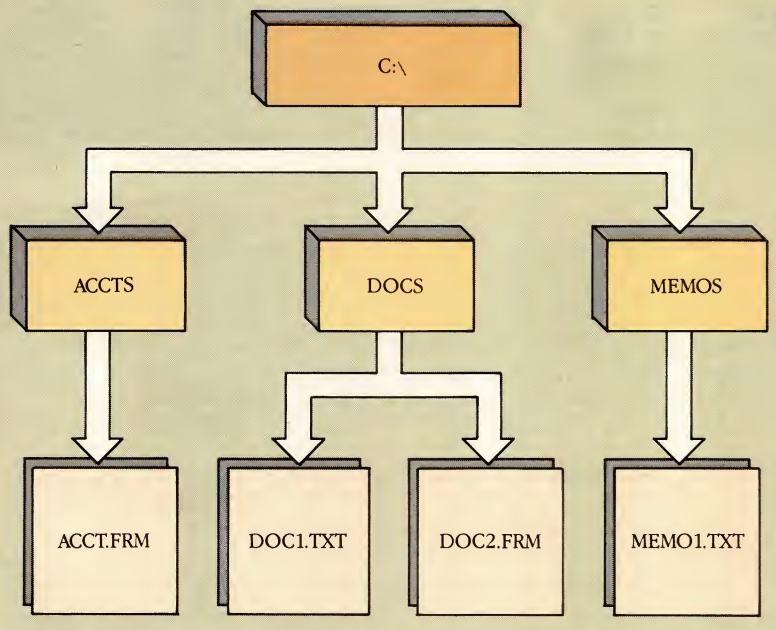
With DOS 3.1 came the SUBST command, which allows the use of a drive specifier to refer to a subdirectory. This provides a transparent service to programs that do not recognize path names. As mentioned earlier, numerous conflicts arise between the substituted drive and other DOS commands, however, leaving this a less than ideal solution.

DOS 3.3 attempts one more time to solve the problem of finding files with the memory-resident utility, APPEND. This command defines a path (which is unrelated to the environment path) for DOS to use to find any file not in the current directory, regardless of its extension. The APPEND path is searched for file names specified in the following function calls: 3DH (file handle OPEN), 0FH (FCB OPEN), and 23H (FCB FILE SIZE).

In addition, APPEND supports two parameters. If /X is specified, the path also is searched on the function calls 11H (FCB SEARCH FIRST), 4EH (FIND FIRST), and 4BH (EXEC). If /E is specified, the current APPEND path is stored in the environment variable APPEND= and can be changed or viewed via the SET command. Otherwise, the APPEND path is stored internally by APPEND. When APPEND is first installed, it requires about 4KB and eats up more memory as the APPEND path increases.

The /X and /E parameters can be specified only on the first invocation when APPEND is loaded into memory. Subsequent invocations of APPEND allow resetting the path (even to null),

FIGURE 2: *Sample APPEND Session*




```
C:\ACCTS>dir *.*

 Volume in drive C has no label
 Directory of  C:\ACCTS

.           <DIR>       6-05-87   2:20p
..          <DIR>       6-05-87   2:20p
ACCT    FRM      5120   1-14-85   3:44p
       3 File(s)  14581760 bytes free

C:\ACCTS>dir doc*.*

 Volume in drive C has no label
 Directory of  C:\ACCTS

DOC1    TXT        10   5-28-87  10:19a
DOC2    FRM     11333   5-27-87   3:07p
       2 File(s)  14581760 bytes free

C:\ACCTS>dir *.txt

 Volume in drive C has no label
 Directory of  C:\ACCTS

DOC1    TXT        10   5-28-87  10:19a
       1 File(s)  14581760 bytes free
```

The /X parameter causes the APPEND path to be searched if DIR cannot find any files in the current directory that satisfy the request. Once file names match the request, the search ends. DIR displays the file names as if they were found in the current directory. In the session at right, the current directory is ACCTS, and the APPEND path is set to C:\DOCS;C:\MEMOS.

but once APPEND is resident in memory, it cannot be removed and its effects reach system wide. The current state of APPEND is passed on to another copy of COMMAND.COM. Any changes made to the APPEND path while another COMMAND.COM is running are passed back to the original COMMAND.COM upon exit unless /E is in effect. However, if APPEND is not loaded when the second copy of COMMAND.COM is executed and the second copy of COMMAND.COM installs APPEND, then the first copy of COMMAND.COM will find APPEND installed when it regains control.

Under APPEND, a program is invoked that resides in another directory from the subdirectory containing the data files, the program can find its associated files automatically. However, APPEND's system-wide effects give rise to incompatibilities. The *DOS 3.3 Reference* warns that XCOPY, BACKUP, and RESTORE should not be used while an APPEND path is in effect if /X is specified, yet the batch-file subcommand IF EXIST uses the APPEND path to find a file *only* if in /X mode.

Unexpected and seemingly inconsistent results occur with the DIR command when APPEND is in /X mode. If DIR cannot find any files in the current directory that satisfy the file specification given, the APPEND path is searched. Once file names that fulfill the request are found in any directory in the APPEND path, however, no further directories are searched. DIR will then display the file names as if they were found in the current directory.

To illustrate this predicament, consider the directory structure shown in figure 2. The current directory is ACCTS, and the APPEND path in /X mode is set to C:\DOCS;C:\MEMOS. The command DIR *.*, or DIR with no arguments, displays the file ACCT.FRM as expected. However, the command DIR DOC*.* displays "Directory of C:\ACCTS" and lists the files DOC1.TXT and DOC2.FRM from the DOCS directory. Finally, the command DIR * TXT lists only the file DOC1.TXT. Because at least one file name has been found to satisfy the query, the MEMOS directory is not searched to produce the file MEMO1.TXT as well.

With or without the /X parameter, a file found through APPEND cannot be renamed or deleted. RENAME returns the error "Duplicate file name or File not found" and DEL returns the error "File not found" without /X and the error "Access Denied" with it. This causes problems with editors and word processors that save the updated version by renaming the old file, writing the edited version to the old file name, and then deleting the original file. Finally, APPEND has no effect on DEBUG—another internal incompatibility. DEBUG does not use the APPEND path to search for files with names that are specified either on the command line or the N (Name) command.

After three attempts, IBM still has not solved the problem of finding all files. The environment path set by the PATH command finds only executable files; SUBST is incompatible with many DOS commands; and the worst attempt yet, APPEND, is both incomplete and incompatible. In /X mode, APPEND is equivalent to PATH for finding executable files, yet it finds data files as well—an appealing situation because only the APPEND path needs to be maintained to find both types of files.

Unfortunately, the /X parameter leads to most of the internal incompatibilities. When APPEND finds a file in the /X mode, the information on the file's location is not made available to DOS (or any program), thus causing problems with DIR, DEL, XCOPY, and

other DOS commands. A solution would be for the function call that found the file to return the complete path name of the file. Then programs would be able to determine the directory in which the file was found and use this information to rename the old file and recreate the original file name. To accomplish this, APPEND would need to be integrated into DOS, not supplied as a resident utility, and programs would need to be aware of the returned path name and use it.

FASTOPEN. Subdirectories, which are so convenient for organizing files into logical groupings, can exact a price when it comes to performance. When the file C:\Admin\Employee\Raises is opened, DOS must first search the root directory on drive C: to find the Admin directory, then search that directory to find the Employee subdirectory, and finally search that subdirectory to find the Raises file. With the memory-resident utility FASTOPEN, the locations of frequently accessed subdirectories and files can be cached in memory so that disk access is minimized. When installing FASTOPEN, the user must define the number of cache entries for each hard-disk drive in the system. The minimum is 10, with a default of 34 per hard-disk logical volume and a system-wide maximum of 999 total entries. Entries are recycled on a least-recently-used basis. Some of the information cached in memory includes the simple file name, its attribute, date and time of creation, beginning cluster number of the file, sector number of its directory, and where in the directory its entry resides.

This is another example of inconsistencies in implementing features. FASTOPEN can be invoked only one time, and once specified, the disks to be cached and the size of the cache cannot be changed. Thus, it would make sense to include this information in the CONFIG.SYS file in the same way that the number of files or buffers is included. In its default state with one hard disk, FASTOPEN requires less than 3KB; its performance improvement should have been made an integral, not optional, part of DOS.

BATCHING IT

With version 3.3, a batch file can execute another batch file as though it were a subroutine by using a new batch subcommand, CALL. The original batch file regains control when the CALLed batch file is finished. Parameters can be passed to the CALLed batch file, including the dummy parameters that were passed to the original file. For example, one batch file can call a second with the command CALL BATCH2 %1 %3. Recursion is supported as long as execution eventually ends, and nesting of batch files is supported to the allowed depth.

Additionally, preceding a batch file command with an @ character suppresses the display of that command even if ECHO is on. This allows for cleaner execution of batch files and is especially useful for suppressing the annoying display of ECHO OFF.

Newly documented in DOS 3.3, the value of environment variables, such as the current path, can be referenced from within batch files by surrounding the environment variable name with percent signs, as in %PATH%. This particular feature has been available (although it was not documented) since DOS 2.0 (see "Environment Variables," Tech Notebook, Jim Vallino, May 1987, p. 51).

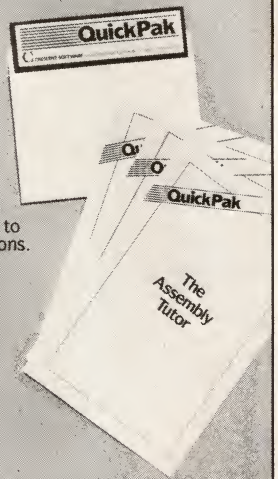
CALLING ALL FUNCTIONS

New features appearing in the DOS 3.3 application program interface include a new function code to the multiplex interrupt and four new DOS function calls (interrupt 21H). Two deal with the foreign-language support. Two others

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CIRCLE NO. 145 ON READER SERVICE CARD

QBase

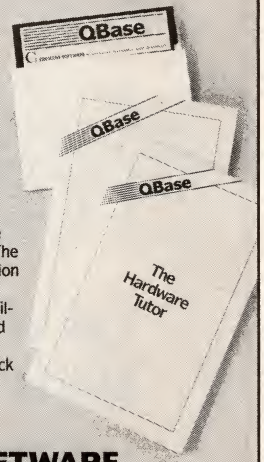
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CIRCLE NO. 144 ON READER SERVICE CARD

are commit file (to flush a file's buffers), and set handle count (to increase the number of handles that are made available to a process).

APPEND. The installed state of the new APPEND command can be queried from a program using 2FH (multiplex interrupt) with function code B7H. In previous versions of DOS, the function codes 80H through FFH were available to programs for interprocess communications. DOS 3.3 uses B7H and recommends that programs use only function codes C0H through FFH.

Commit file. Designed for speed enhancement as well as data security, the new function call 68H (commit file) causes the data in buffers to be flushed immediately to the file. Previously, to ensure that data would be written promptly to the file, programs needed to close and reopen a file to flush its buffers, or they needed to create a duplicate file handle and then close it. The commit file function call now does more quickly and simply what used to require two function calls and, in the second case, an additional file handle.

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```
begin
clrscr;
writeln('                                                          ');
writeln('                        XO-SHELL                          ');
writeln('                                                          ');
writeln('  XO-SHELL is a memory resident program which provides the user ');
writeln('  the following capabilities while running an application:      ');
writeln('    ■ Any IBM-PC character can be input as easily as regular    ');
writeln('      ASCII characters. Vertical or horizontal lines can be     ');
writeln('      easily drawn by choosing graphics characters from a pop-up');
writeln('      window. You can draw forms like this in your code or      ');
writeln('      create simple forms for office use within minutes.        ');
writeln('    ■ XO-SHELL provides a background print spooler. You can     ');
writeln('      print files without leaving an application. The spooler   ');
writeln('      can be started and controlled any time within the         ');
writeln('      application. A typewriter function also enables you to    ');
writeln('      control the printer within your application.              ');
writeln('    ■ The print spooler automatically sends down your printer   ');
writeln('      setup string, and prints a header line on every page      ');
writeln('      including current date, title, file name, file creation   ');
writeln('      date and the page number.                                 ');
writeln('    ■ Any file can be viewed while in an application, and any   ');
writeln('      section of that file can be transferred into your editor. ');
writeln('      Any section of the viewed file can also be printed without');
writeln('      leaving the application.                                  ');
writeln('    ■ A fast search finds, displays and prints strings from     ');
writeln('      files.                                                    ');
writeln('    ■ A notepad and simple editing function enables you to      ');
writeln('      create or modify other files while in an application.     ');
writeln('    ■ A DOS command editor allows you to retrieve, edit and     ');
writeln('      reexecute previous DOS commands.                          ');
writeln('    ■ XO-SHELL provides a scrollable directory display.         ');
writeln('                                                          ');
end.
```

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CIRCLE NO. 154 ON READER SERVICE CARD

Set handle count. Through the new DOS function call 67H (set handle count) a process can increase the number of handles available to it. To understand exactly what this means, it is important first to realize the distinction between handles and open files.

When DOS is booted, memory is reserved for file-control blocks—tables where DOS stores information about open files. These file-control blocks are similar in function to the FCBs introduced in DOS 1.0, but are different in that they are managed by the operating system, not the programmer. The number of open files (and, therefore, the number of file-control blocks that DOS needs to reserve) is set through the FILES= command in the CONFIG.SYS file. The total number of all files that can be open concurrently by all processes ranges from the default of 8 to the system maximum of 255.

A handle is an identification number assigned to open files and, in effect, acts as an index into the table of file control blocks. The default number of handles available is 20. Three DOS function calls—3DH (OPEN), 45H (DUP), and 46H (FORCDUP)—each assign a handle to a file, so the same open file can be referred to by multiple handles within the same process.

When a process begins, DOS allocates five handles to the standard I/O devices: input, output, error, auxiliary device, and printer. However, the standard input, output, and error handles refer to the same file-control block, so only three blocks are used—these blocks are allocated to each process.

The OPEN function call used one file-control block and one handle. The DUP function call uses an additional handle but not a file-control block. (DOS simply increments the file-use count in the file-control block.) However, the FORCDUP function call may or may not require an additional handle, depending on whether the target handle is already in use. If so, the file it referred to is closed and the handle is reused. When a file is CLOSEd (3EH), the handle is released; the file-use count is decremented; and, if the file-use count is zero, the file-control block is released. When a process terminates, all open files are closed. The number of file-control blocks released depends on the file-use counts.

An interesting case occurs when one process EXECutes (4BH) to another. When the child process begins executing, it inherits all the files of its parent that were opened with the inheritance flag set to 0. Similar to DUP,

the number of file-control blocks allocated remains unchanged; the number of handles in use when the child process begins depends on the number inherited from the parent.

If the default number of handles is not sufficient for a particular process, then the DOS 3.3 set handle count function call allows the maximum number of handles per process to be set to any number between 20 and 65,534. Be aware that this function call affects only the number of handles available to a process, not the number of file-control blocks. The system-wide maximum for open files remains the same as that set through the FILES= statement that is in the CONFIG.SYS file.

An undocumented feature of DOS (and, therefore, one that is subject to change) is the storing of the handle table in the program segment prefix (PSP) at offset 18H. The table is 20 bytes long: one byte per handle with each byte holding the number of the file-control block to which the handle refers. Beginning with DOS 3.0, the number of handles allocated is stored in a word at PSP offset 32H, and the address to this table is stored in a double word at PSP offset 34H. When the set handle count function call is executed, DOS creates an extended handle list and resets the handle count and adjusts the address in the PSP to point to the new extended handle list.

Naturally, in order to increase the number of handles, the process must first release memory. The amount of memory DOS needs to allocate is one byte per handle, which is rounded up to a paragraph boundary, plus one

THE YELLOW BRICK ROAD TO OS/2

Operating System/2 (OS/2), announced by IBM and Microsoft at the time of the release of the Personal System/2, promises to be a genuine operating system of the type used on minicomputers and mainframes. OS/2 boasts the following capabilities:

- It breaks the 640KB barrier, using the entire address space of the 80286 microprocessor—as much as 16MB of physical memory.
- It breaks the 16MB barrier by using virtual memory management, making available a maximum of 1GB of virtual memory by swapping memory pages out to disk.
- It provides two levels of multitasking: (1) by concurrent execution of programs (invoked by either the user or other programs) and (2) by concurrent execution of two or more paths within a program.
- It runs in protected mode, providing hardware-enforced isolation between concurrent tasks, so that a failing program cannot corrupt the data or crash another program. Protected mode also precludes programs from directly communicating with the hardware (such as I/O ports) without the operating system's permission.
- It supports code sharing, which means that multiple instances of one program can execute concurrently with only one copy of the executable code in memory.
- It provides dynamic call linking, allowing system or application routines to be loaded when executed, not when executable files are constructed by the linker.

Only programs written for OS/2 can take advantage of these features. However, OS/2 provides two levels of compatibility with old programs and old DOS-based systems. First, most existing DOS programs will run under OS/2 in DOS Compatibility Mode, although only in single-tasking mode and subject to the 640KB memory limitation. Second, new programs written to take advantage of only a specific subset of OS/2 features (the Family Application Program Interface) will run under both OS/2 and DOS 3.x. The file system is unchanged from DOS, meaning that either operating system can read the same disk.

OS/2 also is noteworthy for what it cannot do. Because of the DOS file system, OS/2 cannot handle disk partitions larger than 32MB. (In effect, this imposes a 32MB limit on the virtual memory space.) Second, although it runs on 80386-based machines, OS/2 does not take advantage of any of that processor's special features. Just as the 80286 running DOS is basically a faster 8086, the 80386 running OS/2 is only a faster 80286. Third, OS/2 makes no improvement in the user interface; at least in the initial version, it uses the same "glass teletype" with its C:> prompt. Microsoft promises to correct these shortcomings.

Speaking of versions, the dynamic link facility provides a means of extending the functionality of the system by adding or replacing routines without modifying the operating system kernel. Two major enhancements that will use this mechanism have been announced. The first, under joint development by IBM and Microsoft, is the Presentation Manager, a graphics-based windowing interface (evolved from Microsoft Windows) that offers an alternative to the standard command-line interface. The other, OS/2 Extended Edition, is from IBM and will have database and communications facilities.

OS/2 is currently available directly from Microsoft in a Software Development Kit (SDK). Selling for the hefty price of $3,000, this toolkit includes: a beta-test version of the operating system; a C compiler, assembler, and linker for creating protected-mode applications; various other development utilities; specifications (without source code) for the LAN Manager; a one-year subscription to DIAL, Microsoft's technical support bulletin board; the opportunity to attend a three-day technical seminar led by a group of experts from Microsoft; and a promise of updates and fixes to both software and documentation until the release of the production version, which is scheduled for the fourth quarter of 1987.

At that time, OS/2 will no longer be available from Microsoft, but only from OEMs who will tailor it to specific hardware. The version supplied in the SDK runs on the PC/AT, the Compaq Deskpro 286 and 386, and the Intel Inboard 386; it does not run on any of the PS/2 models. Microsoft would not be specific about the schedule for PS/2 support, or even whether such support would be available before OS/2 is released by IBM in 1988. It should be noted that no documentation or source code for the Presentation Manager is included in the initial release of the SDK.

OS/2 is not meant to replace DOS 3.3; too many applications run just fine under the old environment. But, as DOS slowly sinks under the weight of additional features tacked onto its spartan frame, an alternative to support more advanced applications is urgently needed.

—TM

PC Tech Journal *is currently performing an in-depth evaluation of OS/2 and will publish a comprehensive analysis in an upcoming issue.*

—WF



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CIRCLE NO. 181 ON READER SERVICE CARD

more paragraph for the DOS memory-control block. However, be warned that this function call contains two memory-allocation bugs. When an even number of handles is requested, DOS allocates an extra 64KB of RAM in addition to the amount required. Also, when nearing the 65,534 maximum, DOS attempts to allocate more memory than exists; the system hangs when the program exits and will need to be rebooted. It is unbelievable—and, indeed, unforgivable—that IBM did not test this function call thoroughly and especially that it did not test boundary conditions. IBM is aware of the bugs now, but said they would not be corrected until the next release of DOS.

DOCUMENTATION AND DOLLARS

With DOS 3.3, which replaces both versions 3.2 and 3.1, IBM has reorganized its packaging. DOS itself is distributed on two 5.25-inch (360KB) diskettes and one 3.5-inch (720KB) diskette. Both types of media are supplied together. The 5.25-inch Startup diskette contains all the files necessary to select a country and to install DOS on a hard disk, including device drivers, SELECT, FDISK, and FORMAT. The Operating diskette contains the DOS external commands as well as DEBUG and BASIC. The 3.5-inch disk contains both the Startup and Operating files, and, in a departure from IBM's normal procedure, it is not permanently write-protected, so users must take care not to overwrite the DOS files.

Unfortunately, the *DOS 3.3 Reference* contains numerous errors. Some errors from the *DOS 3.2 Reference* were corrected, but others were left alone. On top of this, the new manual introduces additional errors.

The *DOS 3.3 Technical Reference* is now more than just documentation; it also includes a Utilities diskette in both 5.25- and 3.5-inch form. The biggest difference is that the programmer's tools LINK and EXE2BIN and their documentation have been deleted from the DOS disks and moved to their proper place in the *Technical Reference* package. IBM has added a simple LIB program that is functionally equivalent to the one provided by IBM with the BASIC Compiler and MASM and by Microsoft with its languages. VDISK.ASM is supplied in place of VDISK.LST and is a much more useful form for making modifications. DEBUG comes with both DOS 3.3 and the *Technical Reference*, but is documented only in the *Technical Reference*. A welcome (and long overdue) addition is the DOS 3.3 Technical Quick Reference card that summarizes the DOS interrupts, gives the input parameters and output conventions for DOS function calls, lists error codes, and describes the structure of a directory, FCB, BIOS parameter block, PSP, device header, and request header.

DOS'S LAST DANCE

DOS is suffering from old age. Design decisions made years ago when systems were simpler and smaller are crippling the implementation of new functions. FORMAT's conglomeration of parameters, each with a different meaning, shows the difficulty of adding support for disk sizes unheard of in earlier days. Yet, if IBM had originally made capacity the parameter for FORMAT, instead of the number of sides or number of sectors per track, these inconsistencies would not have arisen.

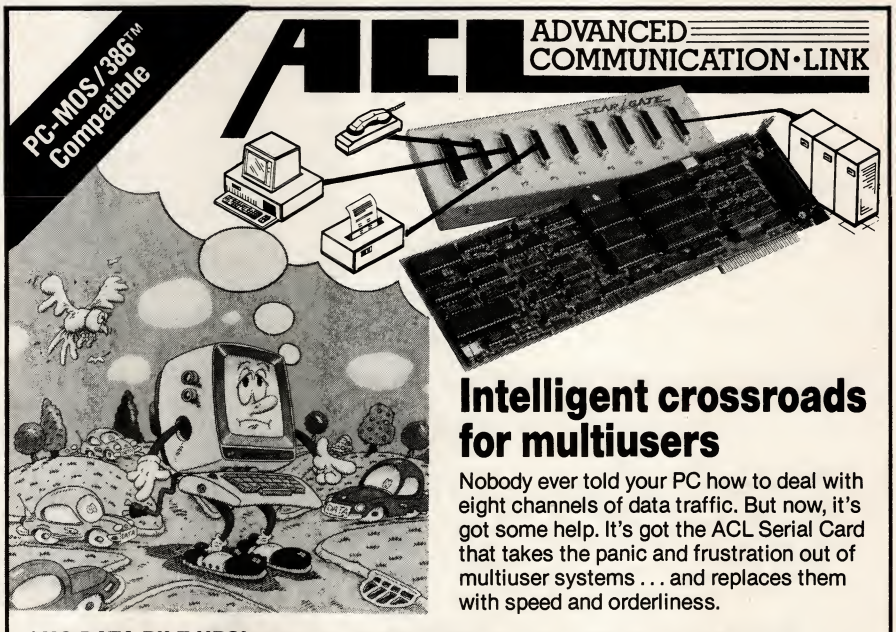
IBM's overriding desire for compatibility with previous DOS versions results in added-on features that do not take effect until specifically requested —even features that are universally useful, such as automatic formatting of backup disks and FASTOPEN. This is carrying compatibility to extremes; upward compatibility is all that any user really wants or needs.

The problem of finding files still has not been solved. While APPEND can be useful in limited, specific circumstances, it is incompatible with many existing DOS functions and must be used with extreme care.

As of July 10, 1987, DOS 3.1 and 3.2 are no longer being sold, and OS/2 is not yet available (see the accompanying sidebar), so buying DOS 3.3 appears to be the only recourse (even though IBM continues to sell DOS 2.1). Instead of providing a cohesive, integrated package, IBM offers an aging operating system, saddled with patchwork parts and piecemeal additions, that has inconsistent interfaces and internal incompatibilities.

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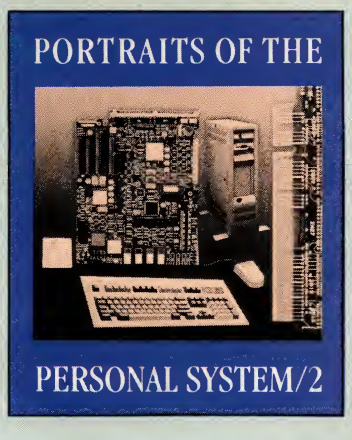
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Emerging 3270 Coherence

IBM micro-mainframe connections take a step up with PS/2. Announced products, including the 3270 Workstation Program, suggest that IBM's aim is a coherent line.

MARY DEWOLF

IBM's micro-mainframe communications picture is finally coming into focus. New 3270 products that have been announced in conjunction with the Personal System/2 models fill in unfinished parts of the picture and consolidate others.

The company's most significant announcement is the 3270 Workstation Program. Where formerly a separate machine (3270-PC) and control software were necessary to achieve integrated 3270 and DOS capabilities, the Workstation Program brings those same capabilities to the PC and PS/2 families. To provide the expanded memory required for serious use of the Workstation Program, IBM released the Expanded Memory Adapter (XMA) in three versions: the original expanded memory board for the 3270-PC; a 2MB XMA for the PC/XT, PC/AT, and Model 30; and a 2MB XMA/A for the Micro Channel machines, Models 50 and 60. The XMA/A is scheduled to be available in October 1987 (see photo 1).

IBM also introduced versions of the 3270 Emulation Program to support the PS/2 family. It has repackaged PC/XT and PC/AT add-on 3270 communications boards for use with the Model 30, and introduced Micro Channel versions of these boards for the Models 50 and 60 (see photo 2). Boards for the Model 80 (which are likely to be similar to those already available for the Models 50 and 60) are scheduled for release in September 1987. Not all of the products covered here are new and others are not yet available, but looking at them as a whole is more and more appropriate as IBM begins to pull together the communications picture (see table 1).

Hardware support for 3270 communications currently includes coaxial cable, token-ring network technology, and modem connections. Current 3270 emulation software provides four levels of sophistication, and all but the entry-level programs support all three of the hardware options.

The standard coaxial connection for 3270 communications is the 3278/79 adapter or its Micro Channel equivalent. Although the coaxial board is, in most cases, connected to the mainframe through a cluster controller, it also can connect directly to a 3724 communications controller and to some 4300 mainframes.

The token-ring connection is established with the Token-Ring Network Adapter or its Micro Channel version, the Token-Ring Adapter/A. PCs connected in this way can access the mainframe through a 3720/25 communications controller, a 3174 cluster control-

ler, or another PC on the LAN that is acting as a gateway.

Finally, the remote modem connection is established using either a synchronous data link control (SDLC) adapter or the Micro Channel multiprotocol adapter, each of which provides direct-dial access by emulating the 3274 cluster controller.

For applications, the new Graphics Data Display Manager/PC link (GDDM/PCLK) and the previously announced Enhanced Connectivity Facility (ECF) support the top three levels of emulation software and all three hardware options. IBM further encourages the development of PC-host application programs with a sequence of upwardly compatible programming interfaces that ease migration from entry-level to top-of-the-line software.

The emulation software and host-access facilities are now offered in four distinct levels of capability, ranging from a single-host session to multihost and multi-DOS sessions (see table 2). Options include the 3270 Emulation Program Entry Level, 3270 Emulation Program, and two that use the 3270 Workstation Program. All four options are available for XT, AT, and PS/2 hardware using DOS, and all but the entry-level software support the full range of physical connections (see table 3).

The 3270 Emulation Program Entry Level uses a control unit terminal (CUT) mode coaxial connection board to emulate the 3278 terminal, which provides no alternate screen sizes and a maximum of four colors. It includes an applications programming interface (API) that is a small subset of the API facilities available with the top-of-the-line Workstation Program.

The next level, 3270 Emulation Program, can use a distributed function terminal (DFT) mode coaxial connection board, a modem, or a token-ring connection, with or without a cluster controller. It provides a combination of three programs; in addition to emulating the 3278 terminal, it can act as its own 3274 cluster controller for direct host connection or as a gateway for other PC stations that are situated in a token-ring network.

When the gateway function is configured with a cluster controller, it provides a different application of DFT mode: instead of displaying multiple logical units (LUs) on a single screen, it directs each of five possible sessions to a physically separate PC. When used as a modem or token-ring connected gateway, the Emulation Program emulates a 3274 controller supporting a maximum



of 32 subsidiary PC stations that are acting as 3278 terminals.

The 3270 Workstation Program implements the two high-level options. In one, it provides multiple host sessions; in the other, it delivers both multiple host and multiple DOS sessions in whatever combination can be loaded into memory (see photo 3). Originally crippled by expensive hardware, DOS incompatibilities, and memory shortages, the 3270 control program has been given new life by being provided access to the standard PC hardware as well as its own memory-expansion board.

Although multiple host sessions have been available from other vendors for some time, they have been restricted to a single physical connection. The Workstation Program can support both LAN and direct-dial connections and can even use different physical connections for different host sessions. A windowing screen manager allows the user to view multiple sessions concurrently. The manager works entirely in text mode, eliminating the need for a graphics-display card.

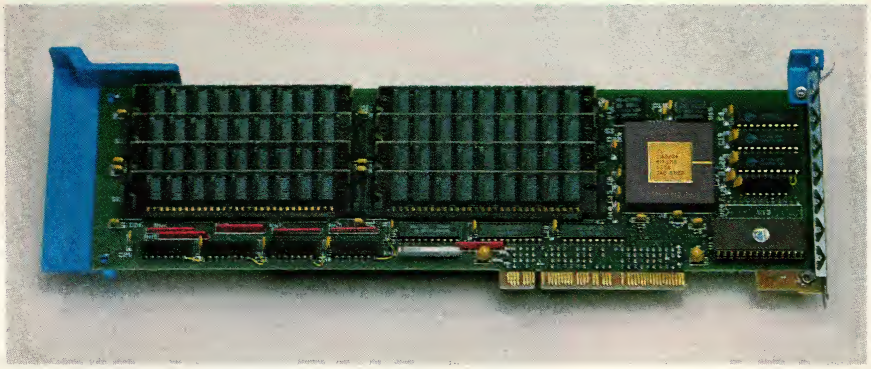
On all but the Model 80, the XMA specialized bank-switching memory board alleviates the memory problems that are generally associated with multiple DOS sessions. Hardware-dependent code in the Workstation Program uses this XMA board—and only this board—to provide alternate banks of memory for various tasks. This elegant solution is marred by the board's inability to coexist with conventional add-on memory. In Micro Channel machines, other system RAM is automatically disabled while the Workstation Program is executing, limiting available memory to 2MB. On non-Micro Channel machines, only one XMA board can be installed, and existing memory must be stripped to 256KB in order to install the XMA board, limiting total physical memory to 2.25MB. Memory is divided among DOS, virtual disk, and XMA during initial program loading (IPL), using device drivers resident within the Workstation Program. Thus, expanded memory is unavailable when the program is not running.

An XMA board also may deteriorate total performance. In its documentation, IBM warns that an AT using more than 480KB in a DOS application "may perform at speeds comparable to . . . an XT." The same warning is issued for the Model 30, but not for the Micro Channel machines.

The Workstation Program will work at its most advanced level on the Model 80. Although still limited to 2MB of memory, the program will not re-

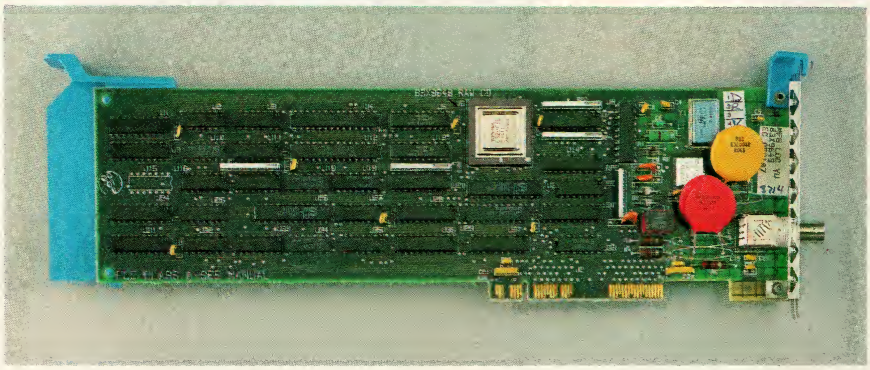
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PHOTO 1: *Micro Channel 2MB XMA/A Board*



This Expanded Memory Adapter/A (XMA/A) board enables the 3270 Workstation Program to run on Models 50 and 60. It will be available in October 1987.

PHOTO 2: *Micro Channel 3270 Connection Board*



The Micro Channel 3270 Connection board for Models 50 and 60 is available now. A version for the Model 80 is scheduled to be available in September 1987.

quire its own XMA board, but instead will take full advantage of the machine's 80386, solving its memory and session-switching requirements by using the 80386's virtual 8086 mode.

WORKSTATION CONTROL

A set of commands collectively called *workstation control* manages the multiple sessions. These commands allow the user to jump from one session to another, copy data between sessions, and alter window sizes, colors, and locations. One of its most popular features allows the user to control screen attributes from the keyboard. The user also can change colors and set blink and reverse video window by window.

Instead of using a menu, the Workstation Program assigns special keystrokes to workstation-control functions. This approach favors the experienced operator over the novice (indeed, it evolved from the complicated keyboard of the 3270-PC). Adding workstation control to a keyboard that already accommodates the 3270 and PC keys produced a 111-key keyboard on the 3270-PC that included two rows of function keys: one was labeled PF1 through PF24, the other F1 through F12—plus red, blue, and magenta designations. Included in this plethora of keys were Esc, End, Finish, two Enter keys, keys that worked only in host mode (or only in PC mode or only in workstation-control mode), and keys that worked in all modes, but behaved differently, according to the mode. Users had to distinguish between the Copy key and the Copy command and know when to use the blue labels and when to use the black labels.

The special function keys of the 3270-PC keyboard have been replaced on the 101-key Enhanced Keyboard by obscure combinations of three or more keystrokes beginning with Shift-Esc. For example, the user who wants to make a window background display as green must push Shift-Esc, Shift-F12, and Shift-Alt-F3. (Fortunately, do-it-yourself key masks are offered for the Workstation Program.) Some functions simply are not available on the older XT and AT keyboards.

The workstation interface is also a disadvantage for the novice. Far from intuitive, it introduces entirely new concepts to execute old, familiar programs; further, the documentation abounds with new terminology. Although the tutorial provided with the product begins well, the workstation control is so versatile that many conceptual leaps are required to move from the tutorial to specific usage.

DOS COMPATIBILITY

DOS programs executed under 3270 workstation control can be predefined using .PIF files, which are compatible with IBM's TopView. Programs without .PIF definitions can be executed, but are assumed to be ill-behaved.

DOS-supported functions are not always available when the Workstation Program is executing. Because the program must "own" the display screen and uses higher memory, software incompatibilities can be expected. For example, neither RoseSoft's ProKey nor Personics Corporation's SmartNotes could be run successfully even when they were loaded before the Workstation Program. The ANSI.SYS driver can be loaded, but it is ignored while the program is running. Because the Workstation Program loads COMMAND.COM for each DOS session, unexpected results can occur when the user alters CONFIG.SYS in one DOS session, then performs an IPL in another.

Multiple DOS sessions, unlike multitasking sessions on multiuser systems, are not entirely independent of each other. Only one session can use the expanded memory, only one can use the ECF, and all must use exactly the same version of DOS. Because these limits are unenforceable, a user could overload the system and end up with a corrupted DOS, a corrupted disk, and a dead system. Worse yet, once in trouble, the Workstation Program is difficult to terminate. If the program considers a DOS session active, it intercepts Ctrl-Alt-Del; this leaves the red power switch as the only method of terminating the Workstation Program—which, of course, promptly disconnects all the host sessions as well.

HIDDEN MULTITASKING

The real potential of the 3270 Workstation Program is not in executing multiple independent tasks, but in integrating multiple functions into what appears to the user as a single application. The Workstation Program allows driver applications executing in one DOS session to control other DOS and/or host sessions behind the scenes. With careful design, a complex array of

TABLE 1: *3270 Connectivity Product Availability*

PRODUCT	DATE AVAILABLE
HARDWARE (for PCs and PS/2 Model 30)	
3278/79 Adapter	Now
Token-Ring Adapter	Now
SDLC Adapter	Now
Expanded Memory Adapter	Now
HARDWARE (for PS/2 Models 50, 60, and 80)	
3270 Connection	Now
Token-Ring Adapter/A	Now
Multi-Protocol Adapter/A	Now
Expanded Memory Adapter/A	10/87
SOFTWARE (for PCs and PS/2s)	
3270 Emulation, Entry Level 1.1	Now
3270 Emulation, Entry Level 1.2	9/87
3270 Emulation	Now
3270 Workstation 1.0	Now
3270 Workstation 1.1 (XMA, Token-Ring support)	1st quarter '88
HLLAPI 3.0	Now
HLLAPI 3.1 (C interface)	2nd quarter '88

These products, when considered as a group, indicate IBM's intent to produce a coherent line of connectivity hardware and software. Some of these products are previous additions to the line and, as indicated, some are not yet available.

TABLE 2: *Terminal Emulation Support*

	3270 EMULATION ENTRY LEVEL	3270 EMULATION	3270 WORKSTATION	3270 WORKSTATION W/MULTI-DOS
Multi-DOS sessions	○	○	○	●
Multihost sessions	○	○	●	●
Non-coax connectivity	○	●	●	●
3278 emulation	●	●	●	●

●=*Supported* ○=*Not supported*

IBM 3270 terminal emulation products offer four distinct levels of capability. The 3270 Workstation Program offers multihost and multi-DOS sessions.

host and PC facilities can take on the look of one seamless operation.

The workstation's copy function, similar to a word-processing cut-and-paste operation, allows the user to copy data from one session's display to another (see photo 4). Using special workstation-control keystrokes to mark the block that is to be moved, the user indicates the destination point and then presses the Copy key.

Because 3270 sessions do not allow copying into protected locations, the copy function is effectively limited to a single screen field. Copying works well among host sessions because the host can read from the screen buffer. Data developed at the PC can be moved to a host session, but moving host data to a DOS session requires some API programming. Only an explicitly enabled DOS session can be the target of a copy operation; it is presumably an API program capable of retrieving data from its presentation space.

The workstation's outbound data-stream preprocessing (ODSP) acts like a device driver for host communications. The workstation configuration defines ODSP as *attached* to a specific host session. It is loaded during workstation initialization and functions as a terminate-and-stay resident (TSR) routine. All 3270 data streams transmitted to the host are first sent to the ODSP, which can alter, lengthen, or shorten data before passing them to the host. However, the documentation cautions against an ODSP performing any functions that would cause a wait, such as disk I/O or API. ODSPs do not have access to data received from the host.

The Workstation Program supports the use of *virtual keystrokes* in the program to transmit data from one session to another. Because the keyboard is the major input source for most PC programs, this capability allows the host to transmit data to existing PC programs. For example, an API program can execute a database query in a host session, then "key" the resulting data into a spreadsheet program that is running in another PC session.

Documented APIs allow PC application programs to invoke workstation services, including communications, workstation control, and operator functions. Because an API enables reading and writing of 3270 structured fields, the workstation is a viable alternative to IBM's APPC/PC (Advanced Program-Program Communications). These structured fields allow programs to communicate outside the 3270 display buffer. Using the **write structured field** command, data can be transmitted between the host and the PC without simulating an Enter keystroke.

This capability eliminates the possibility of unsolicited messages and incomplete responses often associated with program-to-program communication via the screen buffer. It also allows transmission of values beyond the range of the 3270 keyboard. The currently available API documentation is written for assembly-language level and is similar to the DOS *Technical Reference*. IBM also has announced the high-level language API (HLLAPI), but only IBM compilers are supported. A version of the API for C will be released in the second quarter of 1988.

A NEW KIND OF PROGRAMMING

The concept of external integration rather than monolithic programs is a radically different approach to system design. It is catching on slowly, but yielding very impressive results. Using a driver program offers many advantages. With generalized software, the user often must perform individual system analysis, selecting software functions that can be applied to a particular application. This often results in underused or misused software and a poor return on investment. With a driver program, an optimum solution can be shared by many users who need not understand the details of the commands that are involved.

In a complex PC environment with complicated command sequences, a driver application can act as an extended .BAT file, thus permitting a distracting command sequence to be executed by the program. Automating input also can integrate specific appli-

TABLE 3: *3270 Connectivity Support*

	CUT	DFT	TOKEN-RING	SDLC
3270 Emulation, Entry Level	●	○	○	○
3270 Emulation	○	●	●	●
3270 Workstation 1.0	●	●	○	●
3270 Workstation 1.1	●	●	●	●

●=*Supported*
○=*Not supported*

IBM products provide graduated levels of connectivity support, with 3270 Emulation, Entry Level offering the least, and the 3270 Workstation Program, the highest. The latter will work at its most advanced level on the Model 80; although still limited to 2MB of memory, the program will not require its own XMA board.

cations of purchased products that otherwise could not be tailored to a specific application. The specific application need not limit the software's general applicability. Because the linking of functions is external to the program, the cooperating programs remain available for stand-alone use or in other combinations.

Other than keystroke simulation, the facilities provided by the Workstation Program are largely available from the keyboard as well. Custom integration is possible without programming using the Workstation Program's keystroke recording feature (available only with the 101- and 111-key keyboards). Although DOS 3.3 is required (according to IBM), the Workstation that was tested was executed under DOS 3.1 with no apparent problems (the 3.3 requirement may refer to the file-sharing capabilities that are needed for multiple DOS sessions).

APPLICATIONS PARTNERS

The two products that demonstrate the coming-of-age of micro-mainframe applications are ECF, an umbrella for server/requester program interface (SRPI) and several resource-sharing functions, and GDDM/PCLK, which uses PC software to create graphs calculated by the mainframe application.

ECF is a family of host-based LAN functions for sharing data and other resources among PCs, and between PCs and mainframes. These facilities are used as *server/requestor* programs. The server executes at the host mainframe under TSO or CMS; the requestor executes at the PC, invoking the server and interpreting its response.

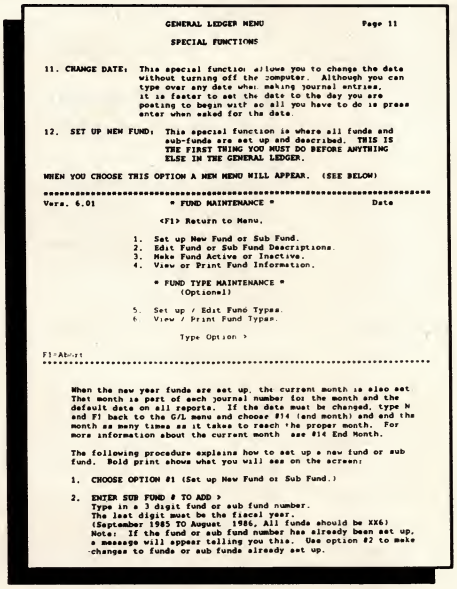
SRPI is the user-program interface that is specific to the host's server functions and a layer removed from the communications facilities that are provided by the emulators' APIs. It is expected that SRPI will be used in OS/2's Communications Manager.

ECF's *virtual disk* enables PC files to be shared among multiple PC users. Although this facility in practice runs too slowly to be used heavily, it is valuable when one user must make PC files available to another user, such as in a corporate budget process, where departmental budget spreadsheets are merged into a divisional spreadsheet.

Virtual print uses host printers as PC peripherals. However, the data must be transmitted before they can be printed, thus precluding the printing of large volume files. Moreover, the host print is spooled through the batch sys-

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From this:


GENERAL LEDGER MENU Page 11

SPECIAL FUNCTIONS

11. CHANGE DATE: This special function allows you to change the date without turning off the computer. Although you can type over any date when making journal entries, it is faster to set the date to the day you are posting to begin with so all you have to do is press enter when asked for the date.

12. SET UP NEW FUND: This special function is where all funds and sub-funds are set up and described. THIS IS THE FIRST THING YOU MUST DO BEFORE ANYTHING ELSE IN THE GENERAL LEDGER.

WHEN YOU CHOOSE THIS OPTION A NEW MENU WILL APPEAR. (SEE BELOW)

Vers. 6.01 * FUND MAINTENANCE * Date

<F1> Return to Menu.

1. Set up New Fund or Sub Fund.
2. Edit Fund or Sub Fund Descriptions.
3. Make Fund Active or Inactive.
4. View or Print Fund Information.

* FUND TYPE MAINTENANCE *
(Optional)

5. Set up / Edit Fund Types.
6. View / Print Fund Types.

Type Option >

F1=Abort

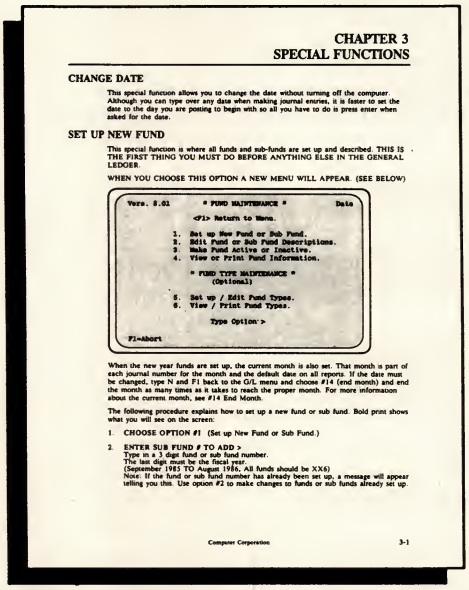
When the new year funds are set up, the current month is also set. That month is part of each journal number for the month and the default date on all reports. If the date must be changed, type N and F1 back to the G/L menu and choose #14 (end month) and end the month as many times as it takes to reach the proper month. For more information about the current month see #14 End Month.

The following procedure explains how to set up a new fund or sub fund. Bold print shows what you will see on the screen:

1. CHOOSE OPTION #1 (Set up New Fund or Sub Fund.)

2. ENTER SUB FUND # TO ADD >
Type in a 3 digit fund or sub fund number.
The last digit must be the fiscal year.
(September 1985 TO August 1986, All funds should be XX6)
Note: If the fund or sub fund number has already been set up, a message will appear telling you this. Use option #2 to make changes to funds or sub funds already set up.

To this:


CHAPTER 3
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(Optional)

5. Set up / Edit Fund Types.
6. View / Print Fund Types.

Type Option >

F1=Abort

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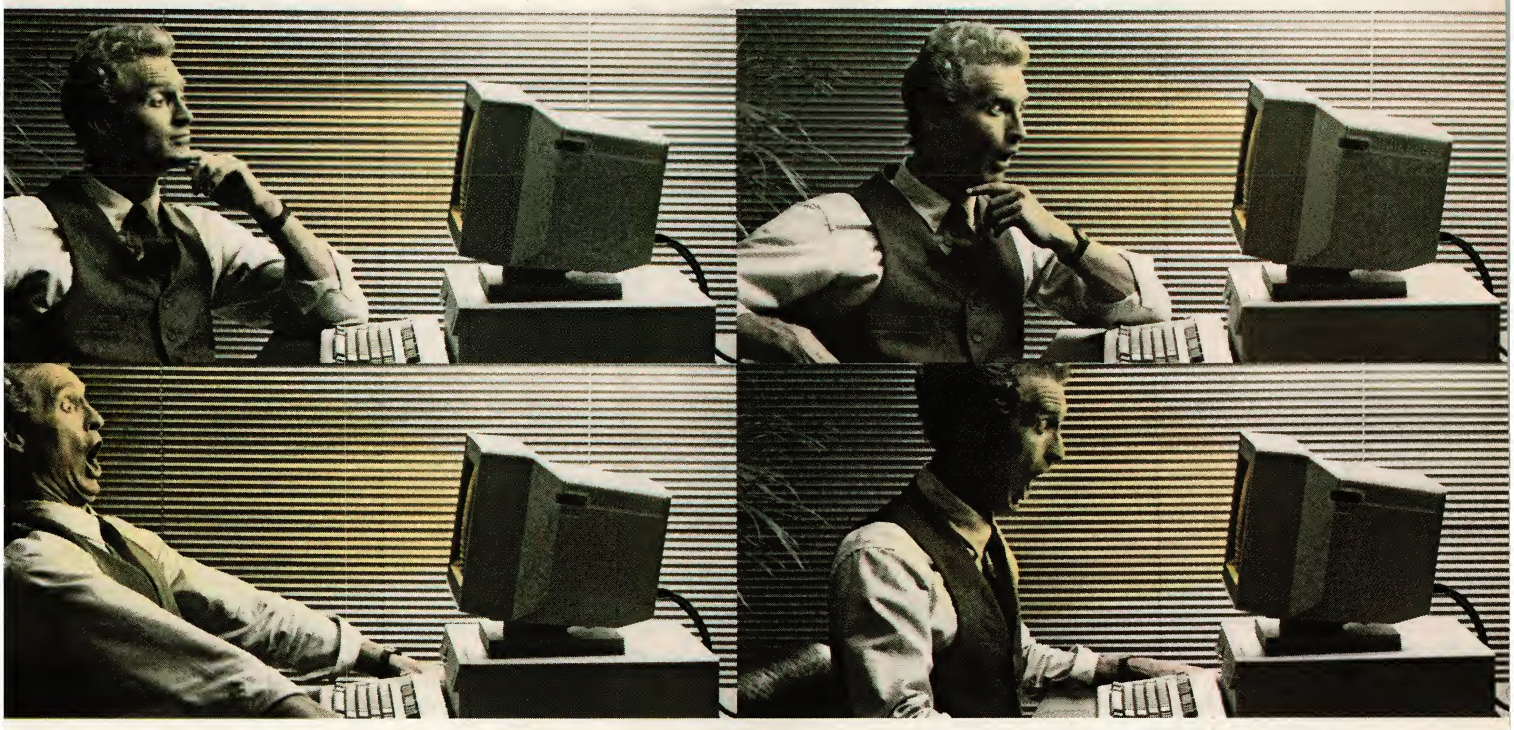


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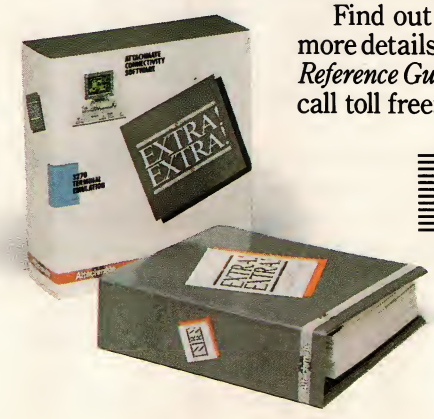
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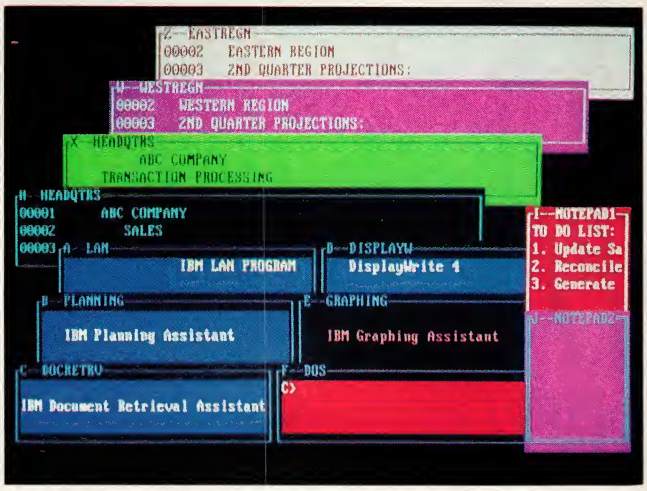
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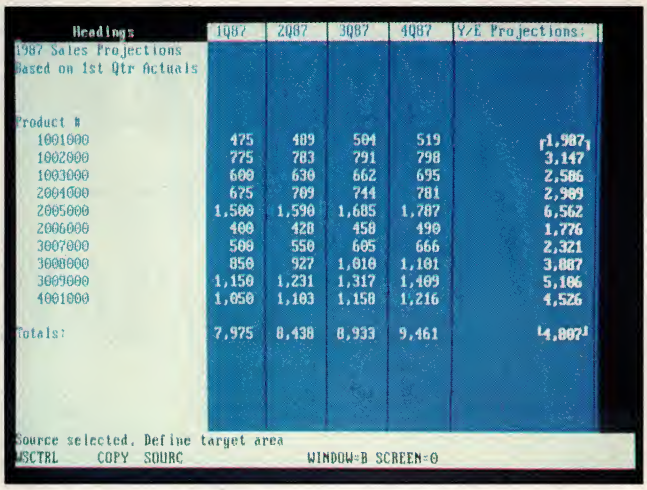
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PHOTO 3: *3270 Workstation Program*



As this screen suggests, the 3270 Workstation Program supports four host sessions, six DOS sessions, and two notepad sessions (including as much as 2.25MB of memory).

PHOTO 4: *Copying Session Data*



Data can be copied from one session to another using a cut-and-paste operation. Special Workstation Control keystrokes are used to mark and move a block of data.

tem, so output may not be immediately available. In addition, many host printers still use only uppercase letters.

Virtual file allows a PC to read and write sequential host files. This facility provides a workable alternative to the simple file transfer, which is limited both by access method and record-format incompatibilities. Under virtual file, the program automatically translates host record formats into formats that can be used on the PC. A PC can execute a program using input from a sequential file at the host, with no intervening downloading or import/export. In such a case, the only restrictions are that translation rules for the host file must be defined in advance and only sequential files are supported.

When running under the Workstation Program, ECF solves the problem of selecting a multiple host session simply by using the first one. ECF's TSO server requires TSO/E release 4 to support the entry-level emulator (release 4 is scheduled to be available in September 1987).

GDDM/PCLK addresses the problem of host access to PC graphics displays. Because of the large amounts of computation and data they generally require, mainframe graphics applications have not been good candidates for migration to stand-alone PCs. At the same time, advances in PC graphics cannot be fully exploited by a host application that is designed to communicate with a 3279 terminal.

Because PCs have varying graphics capabilities, GDDM/PCLK downloads parameters to the PC and lets the PC execute the graphics. Instead of displaying a graph on a host screen, it transmits only the graph's coordinates. The PC user is prompted to switch from the host to a DOS session, where the PC side of GDDM/PCLK retrieves the coordinates that it has received from the host and produces the graph using methods that are appropriate to its graphic-display facilities.

The 3270-PC performs graphics using its own special graphics-display capabilities based on DFT data streams. By comparison, GDDM/PCLK is remarkable for what it does not do: it uses no structured fields or programmed symbols. The host sends vectors to the PC using ordinary cut-mode 3270 screens, and the PC program reproduces the graph to the best of its ability. The PCLK approach eliminates the need for device-dependent knowledge at the host, and allows the PC software to produce a display that is tuned to its graphics capability, without having to emulate another terminal.

In both the ECF and the GDDM/PCLK programs, the PC portion is distributed by a host download rather than by a diskette. This method allows both host and PC components of the software to be packaged and controlled as a single product.

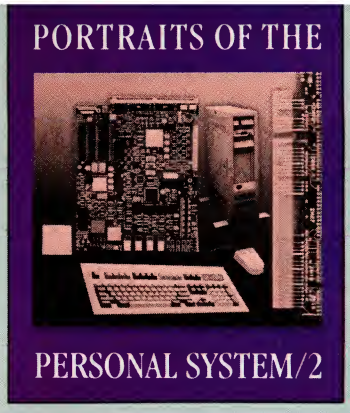
COMPETITION WITH OS/2

The question of OS/2 support for this collection of products has no clear answer. On the surface, they will be supplanted by the Communications Manager to be included by IBM as part of the Extended Edition of OS/2. IBM's announced plans call for the Communications Manager to support communications between PCs and host networks using a variety of protocols including SDLC, DFT to cluster controller, Token-Ring Network, IBM PC Network, and asynchronous links. Both the SRPI and HLLAPI interfaces are expected to be compatible with the Communications Manager, but it is obvious that some Workstation functions will not be directly translatable.

The more interesting question, particularly for the next year or two, is the prospect of competition that could develop between the 3270 Workstation Program and the OS/2 Communications Manager. The Workstation Program's user interface is not compatible with that of the Presentation Manager, and it is doubtful that its Multi-DOS capabilities will be available with OS/2. OS/2 will provide its own graphical user interface and multitasking of programs written to its API. This will allow multisession host communications concurrent with local processing; of course, OS/2 will run only on 80286- and 80386-based systems.

Until the Communications Manager becomes available (its planned availability date will not be announced by IBM until the fourth quarter of this year), and probably for some time to come (especially for the users who do not wish to invest the time and money required to convert to OS/2), the products discussed here will continue to do a serviceable job of providing PC-host system connectivity.

Mary DeWolf is the proprietor of This is How, a Morristown, New Jersey, consulting firm specializing in PC-host applications.



LANs: Toward OS/2

IBM has announced network products to accommodate the PS/2s. As for OS/2, IBM and Microsoft will take separate routes in providing communications capabilities.

DAVID METHVIN

Clearly, the stars of IBM's April product extravaganza are the new Personal System/2 computers, but its new local area network (LAN) products play an important supporting role. Some provide existing capabilities for the new Micro Channel bus; others help unify IBM's network offerings into a consistent, compatible product line. The most intriguing revelations—about the Operating System/2—provide a look at future communications capabilities from IBM and Microsoft.

When this article was written, only the PC Local Area Network version 1.2 and the Token-Ring Adapter/A were available for review; IBM and Microsoft supplied other product information.

Because the PS/2 Models 50, 60, and 80 use the Micro Channel bus, IBM's first order of business is to provide Micro Channel versions of its adapters. All PC and PS/2 models now are supported on all IBM networks. Figure 1 shows the correct adapter to use in each pairing of network and computer. Product names ending in /A indicate new Micro Channel versions.

Through its LAN Support Program, IBM has improved compatibility by providing a uniform set of interfaces. This program offers both the network BIOS (NETBIOS) protocol and the IEEE 802.2 logical link control (LLC) protocol. NETBIOS has been rewritten in assembly language to make it smaller and faster. The LLC protocol is used by IBM's advanced program-program communication (APPC).

IBM's PC LAN Program, version 1.2, improves performance over version 1.1 by caching disk requests—up to 400KB of disk in conventional memory, and up to 12MB in extended memory. Although disk caching is a proven method for increasing performance, its benefits are realized in only some situations (see "The Cache Factor," Maxine Fontana, this issue, p. 168).

PC LAN can support as many as 254 NETBIOS sessions, a considerable increase over the previous 32 sessions. However, the 32-session limit still applies when using the original PC Network Adapter because NETBIOS is on the adapter. Newer adapters use the NETBIOS support provided by the LAN Support Program, which resides in conventional system memory.

However, the functionality of PC LAN has not improved much—it still lacks a good security scheme. According to IBM, "The PC LAN Program version 1.2 utilizes the security and auditability features of IBM PC DOS version 3.1, 3.2, or 3.3." Those features consist of read-only/hidden/system file attributes and time stamp.

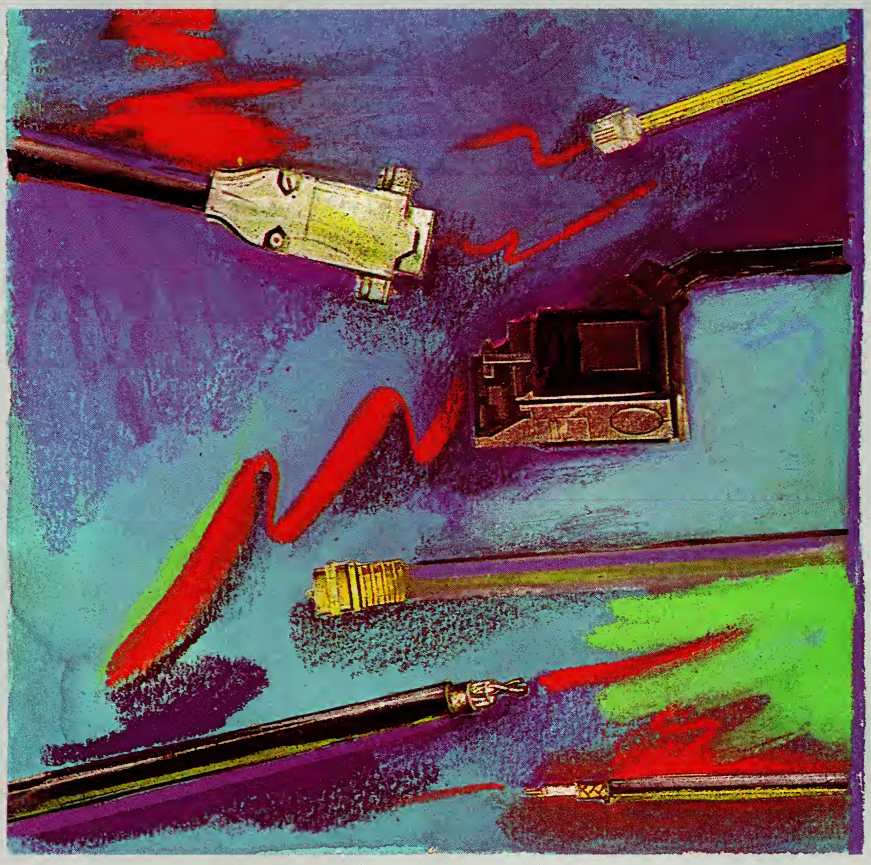


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'OKEN CHANGES

he Token-Ring Network Adapter/A, /hich provides PS/2 Models 50, 60, and 0 with a token-ring connection, has 6KB of RAM on the adapter for buffer- ıg messages, the same as the Token- ing Network Adapter II offered for the C bus (see photos 1 and 2). The origi- al Token-Ring Adapters I and II con- nue to serve the PC, PC/XT, PC/AT, nd PS/2 Model 30.

IBM has replaced the Token-Ring Network Manager with the more capa- le IBM LAN Manager, version 1.0, cheduled for release in December 987. The new program can manage ither a token-ring or broadband LAN, nonitor the LAN for failures or config- ıration changes and report them to the perator, and log events into a disk file or analysis at a later time. When used vith the Token-Ring Bridge Program, ersion 1.1, the LAN Manager can now ontrol the entire bridged network. he Bridge Program also provides con- iguration and performance information o the LAN Manager.

The Token-Ring Network Starter Kit/A provides the adapters, cables, and oftware to create a four-station LAN ısing PS/2 Models 50, 60, or 80; it is quivalent to IBM's original Token-Ring tarter Kit still offered for the PC, XT, T, and PS/2 Model 30. These kits contain everything needed to get a token-ring LAN up and running. However, the software is IBM's PC LAN, and the kits cannot be implemented for users with a combination of the Micro Channel bus and the PC bus.

BROADBAND COMMITMENT

Because IBM uses the term *PC Network* for two very different networks, it is important to distinguish between the *broadband* and *baseband* implementations. IBM has underlined its commitment to its original broadband network product with the release of two new network-interface cards. The first, the PC Network Adapter II, connects to the PC bus for use in the PC, XT, AT, and Model 30; although it delivers higher performance than the original PC Network Adapter, the original adapter can still be used. The second, the PC Network Adapter II/A, connects to the new Micro Channel bus for use in Models 50, 60, and 80.

Unlike the original PC Network Adapter, these products do not include NETBIOS on the adapter itself. Instead, two different software products, the PC Network Protocol Driver and the LAN Support Program, provide NETBIOS services. The 802.2 LLC protocol is not supported with the PC Network Protocol, nor are programs such as APPC/PC.

The IBM LAN Support Program, which provides both NETBIOS and 802.2 LLC, can be used on all IBM networks, including the broadband PC network. However, its low-level protocol is different—the PC Network Protocol Driver supports the low-level protocol originally used in the PC Network. Because IBM provides broader support for 802.2 LLC networks, installations with no significant software commitment to the old PC Network protocol would be well advised to convert to the LAN Support Program.

BASEBAND SUPPORT

The new IBM PC Network-baseband system has unshielded telephone twisted-pair wiring and modular telephone-style RJ-11 jacks. It can be used in a simple daisy-chain configuration, where the output of one network interface card connects to the input on an adjacent card. In this configuration, up to eight stations can be linked over a distance of up to 200 feet.

The IBM 5173 PC Network Baseband Extender is designed for use with larger networks. It has 10 ports, each of which can link up to eight daisy-chained stations. Using the baseband extender, the maximum daisy-chain distance can grow to 400 feet. A fully configured network contains 80

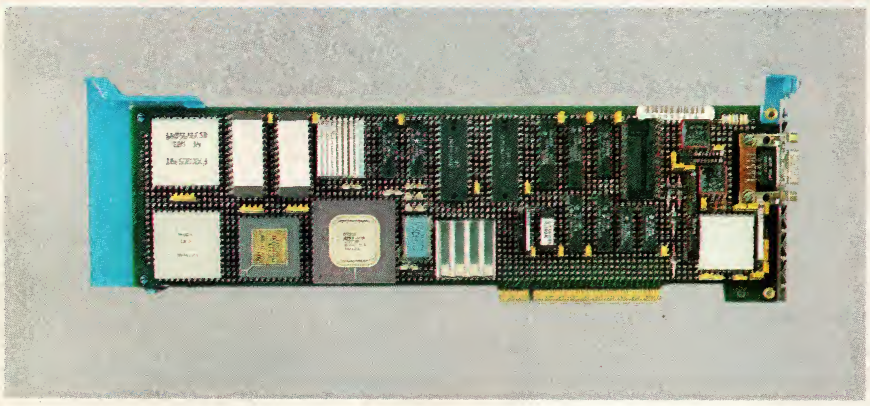
FIGURE 1: *LAN Adapter Selection Matrix*

IBM LAN PRODUCT	PC, XT, AT	MODEL 30	MODELS 50, 60, 80
PC NETWORK—BROADBAND	PC NETWORK ADAPTER PC NETWORK ADAPTER II		PC NETWORK—BROADBAND ADAPTER II/A
PC NETWORK—BASEBAND	PC NETWORK—BASEBAND ADAPTER		PC NETWORK—BASEBAND ADAPTER/A
TOKEN-RING NETWORK	TOKEN-RING NETWORK ADAPTER TOKEN-RING NETWORK ADAPTER II		TOKEN-RING NETWORK ADAPTER/A

Newly announced product Previously announced product

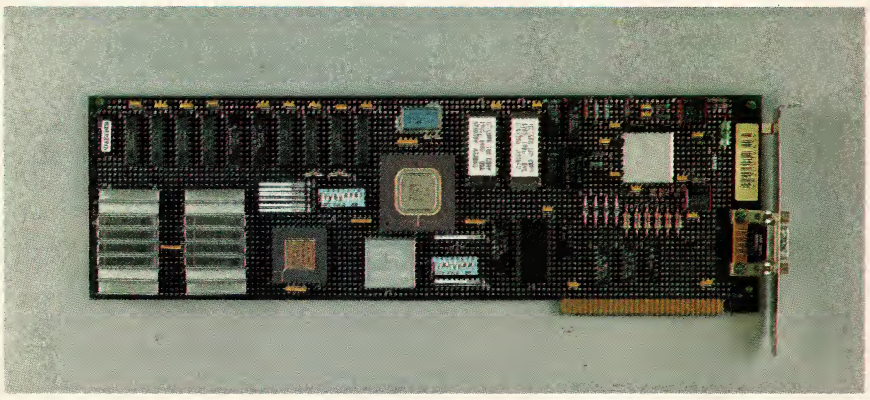
The Micro Channel bus is significantly different from the PC bus and requires different adapters to support IBM's LANs. The new PC Network Adapter II and II/A for broadband systems no longer has NETBIOS built into the card; instead, a separate NETBIOS emulation is provided in the PC Network Protocol Driver.

PHOTO 1: *IBM Token-Ring Network Adapter A*



The Micro Channel version of the Token-Ring adapter uses the Programmable Option Select feature to configure features such as ROM address and I/O ports. The original adapter, below, uses DIP switches to accomplish this task.

PHOTO 2: *IBM Token-Ring Network Adapter II*



PC and PC/AT bus computers, including the low-end PS/2 Model 30, use the original Token-Ring adapter, shown here. This board and the one above share many similar components, and both contain a socket for a remote-boot ROM.

stations within a 400-foot cable radius of the extender.

The resemblance between IBM's PC Network-baseband and AT&T's StarLAN is far from coincidental: the wiring and connection strategies for both networks are the same, and both systems support the IEEE 802.2 LLC standard.

The networks differ at the physical link layer: IBM chose to ignore the extant IEEE 802.3 standard that defines StarLAN in favor of higher speed and smaller network size. Although both networks use the carrier-sense multiple access with collision-detection (CSMA/CD) protocol, IBM's network transmits at 2 megabits per second (Mbps), and AT&T's StarLAN transmits at 1 Mbps. Because twisted-pair media are very susceptible to signal loss and degradation, the doubling of raw bit speed requires that the network size be reduced. In a daisy-chain configuration, StarLAN can accommodate as many as 10 stations over a distance of 400 feet; PC Network-baseband can handle only 8 stations within 200 feet.

The adapter cards reveal one compelling reason that IBM chose the 2-Mbps rate. The bulk of the adapter card circuitry is common to both baseband and broadband PC networks; a separate daughter board plugs onto the adapter to provide modulation for either implementation. Because the original broadband network runs at 2 Mbps, more common circuitry was realized by its being able to run on the baseband network at the same rate.

The PC Network-baseband system provides a simple, easy-to-install, relatively low-cost connection between personal computers. It is cost effective in filling the modest needs of IBM's smaller customers, such as educational and small-office users, whereas the IBM Token-Ring Network is designed for corporate users. For example, IBM's Token-Ring Network Starter Kit/A provides a four-station LAN for $4,710, or $1,178 per station; an equivalent PC Network-baseband kit, assembled from the recently announced products, costs only $2,819 or $705 per station.

IBM/MICROSOFT DIVERGENCE

IBM's upcoming protected-mode DOS product has been officially named Operating System/2 (OS/2). Microsoft has announced it will provide the same operating system, but with the Presentation Manager—a Windows-like interface for third-party developers, under the name MS-OS/2.

IBM intends to expand communications capabilities with its Extended



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MEDIA INTELLIGENCE

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Edition of OS/2; Microsoft separately plans to provide communications capabilities using the MS-OS/2 LAN Manager. IBM is emphasizing connection to its minicomputers and mainframes, using its System Network Architecture (SNA) protocols such as APPC. Microsoft is emphasizing connections among personal computers, using new features of OS/2 and a protected-mode NETBIOS. The decision as to which path to follow depends upon whether the user's needs are centered around mainframes or personal computers.

IBM's OS/2 communications products will not appear until OS/2 Extended Edition version 1.1. IBM will announce its delivery date in the fourth quarter of 1987. It will support five communications interfaces: APPC, NETBIOS, server-requester programming interface (SRPI), asynchronous communications device interface (ACDI), and the IEEE 802.2 LLC. It will emulate IBM (3270, 3101, 5250) and Digital Equipment Corporation (VT100) terminals.

The Microsoft MS-OS/2 LAN Manager (not to be confused with the IBM LAN Manager) ports Microsoft networks, enhanced to exploit the new OS/2 features, to the OS/2 environment. Because the LAN Manager can run in a network with current Microsoft LAN products, including XENIX-Net, an OS/2 system could act as a server to a network of DOS 3.3 workstations.

The built-in multitasking features of OS/2 allow the server to be nondedicated; a user can run applications at the same time that external requests are being serviced. The LAN Manager enhances the capabilities of MS-NET by providing a user-name-based security scheme, a comprehensive print-spooling facility, remote program execution, and a NETBIOS interface.

The most obvious way to move quickly to OS/2 might appear to be the DOS 3.x compatibility box for running existing LAN applications. However, it does not work—communications packages, hardware device drivers, and network-dependent applications do not operate in the compatibility mode.

The user must obtain new protected-mode device drivers for the LAN card being used, and each LAN operating-system vendor must write an OS/2 shell program. Even DOS communications programs such as DCA-Crosstalk Communications' Crosstalk XVI and Headlands Communications' PC-TALK must be replaced by OS/2 equivalents. Installations with a significant investment in networking may find they have a much longer wait for OS/2.



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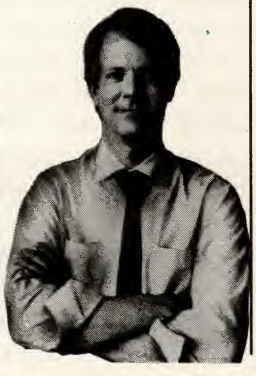
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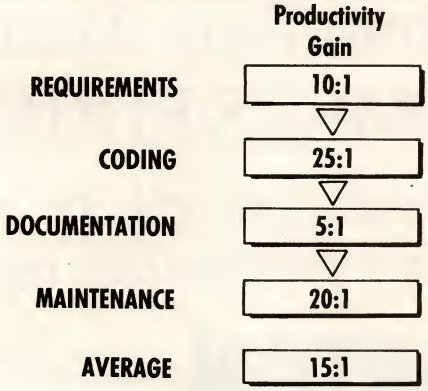
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```
SQL:
SELECT *
FROM WORKONTAB, PROJECTS, EMPLOYEES-
WHERE WORKTONTAB.ENUM = EMPLOYEES.ENUM-
AND WORKONTAB.PNUM = PROJECTS.PNUM-
AND PROJNAME = 'ALPHA'

ZIM:
List all employees workon projects where
projname = 'Alpha'
```

A typical SQL command and the ZIM equivalent.

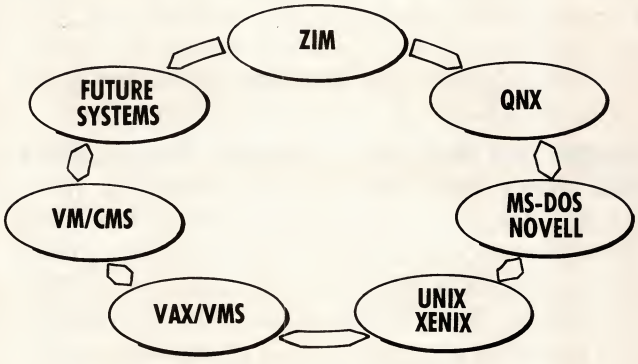
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ZIM 4GL/DBMS: BORN TO RUN ON NETWORKS

The problem with most multi-user LAN database management systems (DBMSes) is that they *aren't*. Often they're lame adaptations of single-user versions or sluggish ports of mini-computer DBMSes. ***ZIM,***® the *natural* multi-user Fourth Generation Language (4GL)/DBMS, is different; ***ZIM*** doesn't just more-or-less *work* on networks, it *runs!*

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Distribution and Network Efficiency

ZIM applications' code and database files may be distributed over any combination of local disks and single or multiple file servers. This arrangement does two important things: it splits up processing tasks over all nodes and it permits different parts of the database to reside where they are most often used. Distributed processing (the first thing) affords maximum *concurrency,* or simultaneous database access by many users. Data distribution (the second thing) also makes for highest network throughput. If the same database application and its data files sat on a central file server, the server would be burdened with all processing tasks *and* all database access requests. The server would become a bottleneck, handling requests in a non-concurrent, torpid fashion.

In a nutshell, ***ZIM's*** facilities for application distribution cut down contention at the file server, maximize concurrency and the best utilize the processing capabilities of a LAN. The net effect is faster, better application *and* overall network performance. No other DBMS does it better than ***ZIM!***

Full Fault-Tolerant Operation ***ZIM*** makes full use of all levels of Novell's ***SFT***™ that are installed, ZIM also explicitly uses Novell's **Transaction Tracking System (TTS),**™ if available on the network, achieving the fault tolerance that high-performance DBMS applications require.

Automatic Locking ***ZIM*** employs a mode of locking that offers the best overall performance over the widest range of applications. All ***ZIM*** commands for updating (ADD, CHANGE, DELETE) use exclusive locks to prevent access by others; commands which only read use shared locks. All locks are released automatically on completion.

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Reviews and Updates



SUPER PC-KWIK
Multisoft Corporation



PERISCOPE, version 3.0
The Periscope Company



POWER METER
The Database Group



FAST TRAX version 3.2
Mark Elfield & Associates

SUPER PC-KWIK

Multisoft Corporation
18220 S.W. Monte Verdi Blvd.
Beaverton, OR 97007
503/642-7108

PRICE: $79.95



CIRCLE 345 ON READER SERVICE CARD

Disk caching, long used on mainframes and minicomputers to improve disk-read performance, is expected to be widely used on microcomputers. IBM introduced a disk-caching program for the Personal System/2 family; Compaq and several software companies offer similar products for use on any DOS machine. Super PC-Kwik from Multisoft Corporation is one such caching program.

These caching programs intercept requests from DOS to the disk device driver. For every disk sector DOS requests, the caching program also reads in several consecutive sectors, saving them in a cache in RAM. Any requests for data from these sectors can be satisfied without time-consuming physical disk operations. This approach is quicker than reading the same number of sectors in several operations because each separate operation encounters rotational delay waiting for the requested sector to come under the read-write head. (For more about caches, see "The Cache Factor," Maxine Fontana, this issue, p. 168.)

Super PC-Kwik is a write-through cache that uses the least-recently-used algorithm to determine how to reuse cache space. Because it is installed as a terminate-and-stay-resident (TSR) program from the DOS prompt or a batch file (rather than as a device driver from the CONFIG.SYS file), the program can be removed on command if no other TSRs are in memory above it. The user also can customize the program extensively with command-line switches. This ability to remove Super PC-Kwik and reinstall it with different parameters allows the user to tailor the cache when switching applications without rebooting the system.

The cache buffer can reside in conventional memory, in extended memory above 1MB, or in expanded memory as defined by the expanded memory specification (EMS). The user can specify the cache size directly or as the memory remaining after reserving a specified amount for other uses.

In conventional memory, the cache size, including both the program and the buffer, can be between 32KB and 600KB. If the user does not specify a size, the program leaves 232KB available for DOS and allocates the remaining memory to itself.

In extended memory, the cache buffer can be between 32KB and 1,024KB; the program uses an additional 25KB to 64KB of conventional memory, depending on buffer size. During installation, Super PC-Kwik recognizes if any extended memory has been allocated to IBM's VDISK (or any other programs using the same allocation technique) and automatically allocates to itself any memory beyond what is already in use. With programs using nonstandard allocation methods, the user must specify in a command-line parameter the address at which the cache buffer begins. By default, Super PC-Kwik uses all nonallocated extended memory up to the maximum.

The program transfers data between a cache in extended memory and a program in conventional memory by switching into protected mode. This approach is cleaner and more portable to the 80386 than other procedures that rely on undocumented methods of addressing memory above 1MB. Its disadvantage is that real-mode interrupts must be disabled in protected mode; if a high-speed communications program is running during the protected-mode transfer, incoming data characters could be lost. To minimize this possibility, Super PC-Kwik allows the user to limit protected-mode transfers to one sector at a time. Although not as efficient as multiblock transfers, this improves the integrity of high-speed communications by limiting the time that interrupts are disabled.

In expanded memory, the cache size, including the cache buffer and most of the program, can be between 48KB and 1,072KB; the program also uses a small amount of conventional memory (10KB to 14KB, depending on page size). If the size is not specified, Super PC-Kwik uses all available expanded memory up to the maximum.

The *page size* is the maximum number of sectors read into the cache at once. If this value is not specified at installation, Super PC-Kwik defaults to the number of sectors on the largest disk track in the system. Because Super PC-Kwik never reads more sectors than those remaining to the end of the track, the user need not set this value larger than the default. However, specifying a smaller value could save memory or optimize performance.

A parameter set during installation allows the cache to be disabled on specified disk drives if, for example, the caching interferes with copy-protection schemes requiring a key disk in a

TABLE 1: *Performance with Various Applications*

	NO CACHE (seconds)	WITH CACHE (seconds)	PERFORMANCE (percent)
Sort 600 records using dBASE III PLUS	64	30	213
Append and index 900 records	38	26	146
Document and tally codes from one column	38	36	106
Compile and link C program	175	168	104
Microsoft Word spell check	32	30	107

The level of improvement gained from installing a disk cache depends upon the type of application. More disk-intensive tasks, such as the database sort, will benefit more with a cache than compute-intensive ones, such as compilation.

TABLE 2: *Cache Fine-tuning*

CACHE SIZE (KB)	PAGE SIZE (sectors) 4	8	17
64	188	207	207
128	200	207	214
256	200	214	221
512	207	221	248
1,024	238	248	258

Figures are performance percentages relative to no cache.

For the disk-intensive database sort, performance increases with both cache size and page size.

diskette drive. However, tests with Lotus 1-2-3 showed no problems, even with caching active.

Measuring the performance improvement provided by a cache requires some care. Many test programs that time artificially contrived operations produce nonsense results when run with a cache. Because performance varies widely depending on the type of application and the cache's operating parameters, users should run their own tests to optimize caching for particular applications. The design of Super PC-Kwik makes it easy to change its operating parameters for each application.

To indicate the range of expected results, table 1 shows performance gains in several applications using one set of cache parameters: a cache buffer of 256KB in expanded memory with a default page size of 17 sectors on an 8-MHz AT with 30MB disk drive. The only test timed with a stopwatch checked spelling using Microsoft Word on an error-free document of 38KB. All other tests are identical to those described in the cache article.

Table 2 shows performance variations when one application, a dBASE III PLUS database sort, was tested using different operating parameters. These results are not meant to be a general recommendation for large cache and page sizes; another task might perform optimally with a different cache set up.

Results also can differ depending on where in memory the cache buffer is installed; these differences remain regardless of the application. Cache performance in EMS was 6- to 12-percent better than in extended mem-

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ory and about 5-percent worse than a cache of equivalent size in conventional memory. Unfortunately, the large cache sizes, which give the best performance, are impossible or impractical in conventional memory.

Super PC-Kwik's documentation is very good; it consists of a 70-page, saddle-stitched manual with a comprehensive table of contents and a useful index. The manual adequately describes the underlying principles of disk caching, as well as the many command-line options that can be used to fine-tune the cache operation. It is not written for the DOS beginner, but then a beginner probably would not find Super PC-Kwik particularly useful. Product support is free and the support staff is quite knowledgeable.

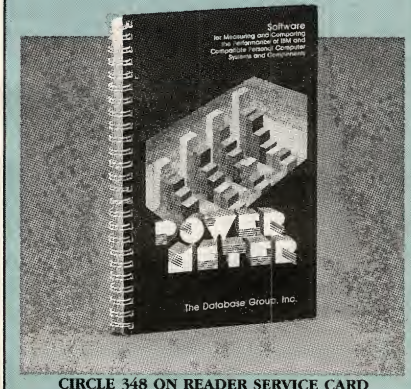
Super PC-Kwik is a high-quality product—well designed and nicely executed—with proper attention to details. Especially now with the PS/2s putting disk caching to good use, many users will want the significant, yet fairly inexpensive, performance advantage provided by PC-Kwik.

—TED MIRECKI

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CIRCLE 348 ON READER SERVICE CARD

Is the video display in the Personal System/2 Model 60 really faster than an PC/AT equipped with screen speed-up software, such as Hersey Micro Consulting's FANSI-CONSOLE? Does the static-column dynamic RAM (DRAM) in the Compaq Deskpro 386 provide better memory performance than the 64KB zero-wait-state memory cache on Intel's Inboard 386? Does a zero-wait-state, 12-MHz 80286-based system deliver the same performance as a 16-MHz 80386-based system? Power Meter answers questions like these by providing a consistent base for comparing performance across a wide range of personal computers and add-in products.

Before Power Meter, the most popular basis for comparing PC system performance was Norton's System Information (SI). It reports system performance as a multiple of the performance of the original 8088-based PC by comparing instruction-execution times. SI provides a good measure for comparing CPU and memory performance but does not address disk-drive speed, video, floating-point calculations, and expanded memory capability.

In addition, *PC Tech Journal* has developed a set of performance metrics to provide raw data on clock rates, access times, and wait states. These metrics allow users to weigh the results according to individual requirements. (See "Compatibility and Performance: Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 70.)

Power Meter combines both approaches. It consists of 23 system and subsystem tests with a menu structure similar to Lotus 1-2-3 (including see-and-point menus and context-sensitive help). Results are given in seconds for simple tests and in Power Meter units for aggregate and system tests that combine results of several subtests with different units of measurements.

The 23 tests can be combined into a weighted index called the Power Meter ratio (PMR), which provides a convenient way to summarize overall performance. Like SI, the PMR is a composite number summarizing a computer's overall performance; unlike SI, it is based on the results of 23 diverse tests. These performance tests include overall system, CPU, memory, disk-drive, and video-display tests. Power Meter uses industry-accepted test programs where appropriate; for example, the CPU and memory tests include the common sieve, whetstone, dhrystone, and nop (no operation) tests.

In system testing, Power Meter attempts to imitate the operation of spreadsheets, word processors, databases, CAD/CAE software, and program-development tools by simulating their most commonly used subfunctions. For example, the program development simulation weighs 10 percent for memory performance, 5 percent for screen, 30 percent for disk, 20 percent for arithmetic expressions, and 35 percent for general CPU-intensive operations. The subset weights (detailed in the RELEASE.DOC file on the Power Meter diskette) cannot be modified.

Power Meter also includes a database to help keep track of all measurements. Each record in the database includes information about the system configuration and the actual performance-test results. Power Meter also compares all other systems in the database with the particular reference system, similar to the way SI compares systems with the original PC.

Power Meter's database feature makes the program more convenient to use from diskette because Power Meter and its database must be carried physically to the various machines being tested, which could require having copies of the program in as many as three different media types. For example, the user might have a copy of Power Meter on a 5.25-inch diskette for conventional PC, PC/XT, and AT testing; a copy on a 3.5-inch diskette for laptop and PS/2 testing; and, a copy on the system's hard disk for later analysis.

Like many new releases, Power Meter has a few minor shortcomings. The most apparent oversight is that all 23 tests cannot run at once; instead, the user must traverse the menu structure to start each test manually—a time-consuming process. Another quirk prevents comparing the test results of the currently executing system with the results of other systems in the database. However, if the user tricks the program into thinking that the current system has not yet been tested, the program will display the results of all systems in the database, including the one currently running.

On start-up, Power Meter tries to determine the particular machine's hardware environment, including its CPU type, amount of memory, disk-drive capacities, math-coprocessor type, BIOS-creation date, expanded memory, and DOS version. When evaluated, Power Meter could distinguish between the 80286 and 80386, but mistook an 80387 for an 80287. The program authors claim these problems will be corrected in a future version.

Despite these minor inconveniences, the benefits of Power Meter far outweigh its weaknesses. The product fills a need by providing a measuring tool for comparing increasingly complicated hardware and software performance-boosting options. With Power Meter, the user can evaluate a

product's performance before committing large amounts of both money and time. Power Meter belongs in every PC manager's tool chest.

—TED FORGERON

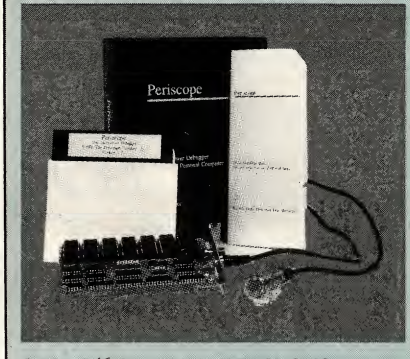
Power Meter's five simulated applications tests were run on the computers examined in "The Cache Factor," (Maxine Fontana, this issue, p. 168). The results were similar to those reported for the database applications without caching software, except that the Compaq Deskpro 286 outperformed the AST Premium/286, followed by the Model 60, the AT, and the Model 50.

—MF

PERISCOPE 3.0

The Periscope Company, Inc.
14 Bonnie Lane
Atlanta, GA 30328
404/256-3860

PRICE: $345, Model I
$175, Model II
$145, Model II-X



CIRCLE 346 ON READER SERVICE CARD

Periscope has built a solid reputation among systems developers as a reliable, cost-effective symbolic debugging tool. Its particular strength is in not interfering with the system environment being tested. Like a conscientious camper, Periscope takes nothing but pictures and leaves few footprints.

Only version 3.0 of Periscope I, II, and II-X is reviewed here and should not be confused with Periscope III, The Periscope Company's newest product that includes hardware monitoring functions. The three Periscope models reviewed have essentially the same commands and features, but come with different hardware. The Model I includes a memory board with 56KB of static RAM to hold the entire Periscope program and all working data, and a push-button switch to activate the nonmaskable interrupt (NMI) signal used for asynchronous breakpoints. Because the memory is write-protected when the target program is running, runaway programs cannot destroy the debugger.

Previous versions of the Model I included only 16KB of memory to hold Periscope's critical data, but not the actual debugger code. (See "Structured Debugging," Jeff Duntemann, Product of the Month, January 1986, p. 29.) The new version better isolates Periscope from the system for added protection against crashes.

In addition, because the entire debugger resides in protected memory above 640KB, the target program loads into exactly the same physical memory whether or not Periscope is being used to monitor it. This provides a distinct advantage in tracking down bugs that change or disappear when the program moves to a new segment.

The Model II includes the NMI switch but omits the protected memory board. It resides in ordinary DOS memory, but otherwise retains all of the capabilities of the Model I. The Model II-X is a software-only version for users who already own an NMI switch (supplied, for example, with IBM's Professional Debug Facility or Atron's PC Probe), or for users content to use Periscope's hot-key facility to simulate the NMI.

A debugger should help users observe and measure the subject program or system without harmful interference. Although most DOS debuggers use DOS calls for both console I/O and read/write files, Periscope bypasses DOS wherever possible, using BIOS for console and direct-disk operations. This independence from DOS is so complete that Periscope can be used to debug even DOS itself.

Periscope is a symbolic debugger with a rich set of commands that are natural extensions of the commands in DOS DEBUG. Like DEBUG, Periscope operates mainly on machine instructions and assembly language. It can show a program's source code (alone or with the assembly-language code interspersed) and allows the user to reference source line numbers as well as symbolic labels or numeric addresses.

Despite its knowledge of symbols and source code, Periscope is not a true high-level-language (HLL) debugger like Microsoft's CodeView (which is included with its C compiler). It currently cannot handle local symbols from .EXE files produced by Microsoft's new compilers and linkers. Even more important for C-language users, Periscope is *not* case sensitive; it converts all symbols to uppercase before comparing them to symbol-table entries. Future versions of Periscope are expected to address both these issues.

However, the two programs appeal to different users: applications programmers use CodeView and systems programmers use Periscope. Although CodeView is more convenient than Periscope for routine HLL applications debugging, Periscope works in places, such as DOS and device drivers, where CodeView cannot function.

In Periscope 3.0, many commands have been enhanced or extended, several new ones added, and some old ones deleted. Arithmetic operators now can be used in nearly any command expression, not just in the hexadecimal arithmetic command. This is very useful in designating interrupt vectors; for example, the command

```
BC {0:21 * 4}
```

sets a breakpoint on the beginning of the DOS system call service routine, pointed to by interrupt vector 21H.

The new SC and SR commands search the current stack for addresses that point to the instruction after a CALL or INT command; the SC command displays the calls found, and SR displays the return addresses. These commands help the user trace backward in order to see how a particular point in the program was reached.

A breakpoint-on-exit command, BX, generates a break when a RET or IRET instruction is executed; this command helps determine where a subroutine returns to its caller. In addition, a user-modifiable comment file labels software-interrupt instructions in disassembled listings. Even the comment

```
MOV AX,0007
INT 10          ; video
```

can greatly assist everyone who is not a walking BIOS reference card.

The new LS and WS commands, which load or write the current symbol table to or from a disk file, can save time in subsequent debugging sessions when the symbol table is large; the normal method of loading symbols from linker .MAP files is much slower. These commands also can be used to save symbols defined manually with the ES (enter symbol) command.

For developers who need maximum performance from their codes, Periscope's new fine-resolution timer can be extremely useful. The F1 func-

tion key enables or disables the timer. When the timing toggle is on, Go and Jump commands start the timer; when Periscope regains control—at a breakpoint, for example—the elapsed time is displayed as an integral number of clock counts, each 838 nanoseconds long. This value is used because it is the fundamental period of the system timer, which generates the timer-tick interrupt every 65,536 counts, or 18.2 times per second.

Periscope's timer is quite accurate for events longer than 20 or 30 clock counts. Very short-duration times are affected by Periscope's entry and exit code, which saves and restores the state of the program being examined. The timer can measure events up to about one hour in duration. The code being timed runs at full speed; no overhead is imposed except at the beginning and end to read the timer.

Periscope's main program, PS.COM, is run once and then remains resident. An auxiliary program called RUN loads target programs and starts the resident debugger. Other utilities are supplied for translating linker .MAP files into Periscope symbol-table files, and for ensuring that the NMI vector correctly points to the debugger. A new program, PSKEY.COM, establishes the hot-key combinations that provide a software NMI (interrupt 2) for asynchronous breakpoints without requiring an actual NMI switch.

A difficult job for systems developers is tracing problems in device drivers. Because drivers are loaded before the user ordinarily gains control, normal DOS-based debuggers are useless for working with drivers, especially during the initialization phase when DOS is not yet fully operational. Periscope version 3.0 has a special device driver, SYSLOAD.SYS (written by Bob Smith of Qualitas, Inc. and licensed to Periscope), which loads ordinary .COM files at CONFIG.SYS time, allowing Periscope itself to be loaded early enough in the boot process so that it can debug other device drivers. Periscope can be given control immediately after loading, or the target device driver can be written to display a message and pause until the user presses the NMI switch. This SYSLOAD-Periscope combination is a clever, yet simple method of debugging device drivers.

Periscope is supported by one of the industry's most reasonable upgrade policies: registered owners receive one software upgrade at no charge, and each subsequent upgrade for $20. The user also can trade up to a higher level (Model II to Model I, for example) for the difference in retail price plus $10. Because the new Model I protected memory board includes more memory, it costs $50 more; other models' prices have remained unchanged.

Periscope sells chip sets to upgrade 16KB boards to 56KB for $20—the user can install the chips and test the board with the diagnostic utility provided. The user also can return the old board to Periscope and for $35 receive the upgraded and tested board. Owners of *very* old memory boards supplied with versions prior to 2.11 must purchase the new 56KB board for $95 in order to use version 3.0.

The newly revised manual is comprehensive, well written, and makes effective use of boldface type to improve readability. Unfortunately, the command section no longer begins each command description on a new page.

Version 3.0 risks displeasing some users by eliminating some rarely used



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CIRCLE NO. 123 ON READER SERVICE CARD

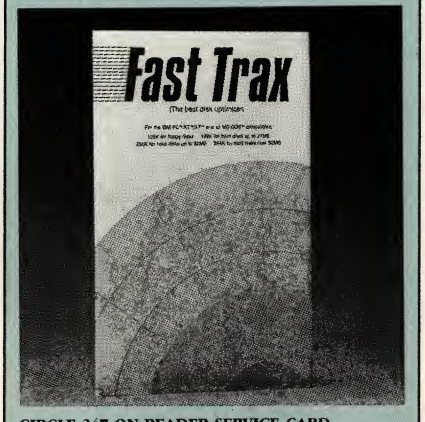
commands and syntactic features. For example, previous versions allowed either an @ sign or a period (.) as a symbol-name prefix; the @ sign is no longer supported. However, no program can accumulate features forever —remaining compatible with every quirk of every previous version—and not eventually crumble under its own weight. If Periscope is to gain power but still retain its unique advantages of small size, protected operation, and independence from DOS, less valuable parts must occasionally be eliminated. Engineering is a constant series of trade-offs, seeking maximum benefit for minimum costs. Periscope is a well-engineered, cost-effective program, now offering its next round of trade-offs.

—THOMAS V. HOFFMANN

FAST TRAX 3.2

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4206 Terrace Street
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415/652-2231

PRICE: $49.95



CIRCLE 347 ON READER SERVICE CARD

Fast Trax is a disk optimizer that improves disk I/O performance by rearranging files and directories to minimize the time required to read them. Designed for use on the PC, PC/AT, and compatibles, it can optimize diskettes and hard disks. Memory requirements, depending on the size of the disk being optimized, range from 128KB for diskettes to 384KB for hard disks larger than 32MB. Fast Trax is not copy protected.

Fundamental to understanding how a disk optimizer works is knowing how information is stored on a disk. The basic unit of disk storage is a *cluster*, which ranges in size from 1,024 to 8,192 bytes depending on the disk's type and formatting. On a disk with 2,048-byte clusters, a 20,000-byte data or program file occupies 10 clusters, which may or may not be stored in consecutive locations on the disk.

If a file's clusters occupy consecutive, or contiguous, locations on the disk, they can be read from the disk with minimum head motion. If the clusters are scattered in various disk locations, the file is fragmented, or noncontiguous. Fragmentation occurs most quickly with files that are regularly read, modified, and rewritten, such as frequently updated database files. The more a file is fragmented, the longer it takes to read the file from the disk because of the time required for the disk's read/write head to seek out the scattered clusters.

Disk optimizers reorganize the allocation of disk space so that all files are contiguous. Fast Trax offers this *consecutive packing* process as an option, but then goes one step further with *optimized packing*. This process not only makes all files contiguous, but also assigns each file and subdirectory to the smallest possible number of disk cylinders. This minimizes the number of *cluster orphans*, or file segments that cross cylinder boundaries. The fewer cylinder boundaries a file crosses, the fewer read/write head movements are needed to access it.

Fast Trax also packs directory entries. When the user deletes a disk file, DOS does not actually remove its directory entry but only marks it deleted. When searching through a directory, DOS looks at all the files, including the deleted files, until it finds the requested file name or the first entry marked unused. By actually removing the deleted directory entries and packing the remaining ones into consecutive locations in the directory table, Fast Trax decreases the time required to search a directory.

With Fast Trax, the user can specify how close to the file allocation table (FAT) each file is stored. The FAT, which is in a fixed location on every disk, contains the location of each file stored on the disk. According to the Fast Trax manual, placing the most frequently used files close to the FAT improves average disk performance: when a file is accessed, the read/write head must move between the FAT and the file itself; the closer the file is to the FAT, the faster the access.

Some copy-protection methods recognize a key disk or authorized hard-disk installation by means of specially coded information contained in one or more hidden disk files. If these files are moved by an optimization program, the special signature may be destroyed. To avoid this problem, Fast Trax never moves a file or subdirectory marked "hidden," "read only," or "system." For complete safety, however, the Fast Trax manual recommends that copy-protected software be uninstalled before optimizing a hard disk.

Using Fast Trax is quite straightforward: it first analyzes the selected disk and then displays, both graphically and numerically, the amount of disk fragmentation. It can optimize the entire disk (or only the fragmented files) and can change the order of files on the disk. To change the file order, the user specifies the desired order in a text file called FASTTRAX.CMD. Fast Trax reads this file during execution and rearranges files and directories accordingly.

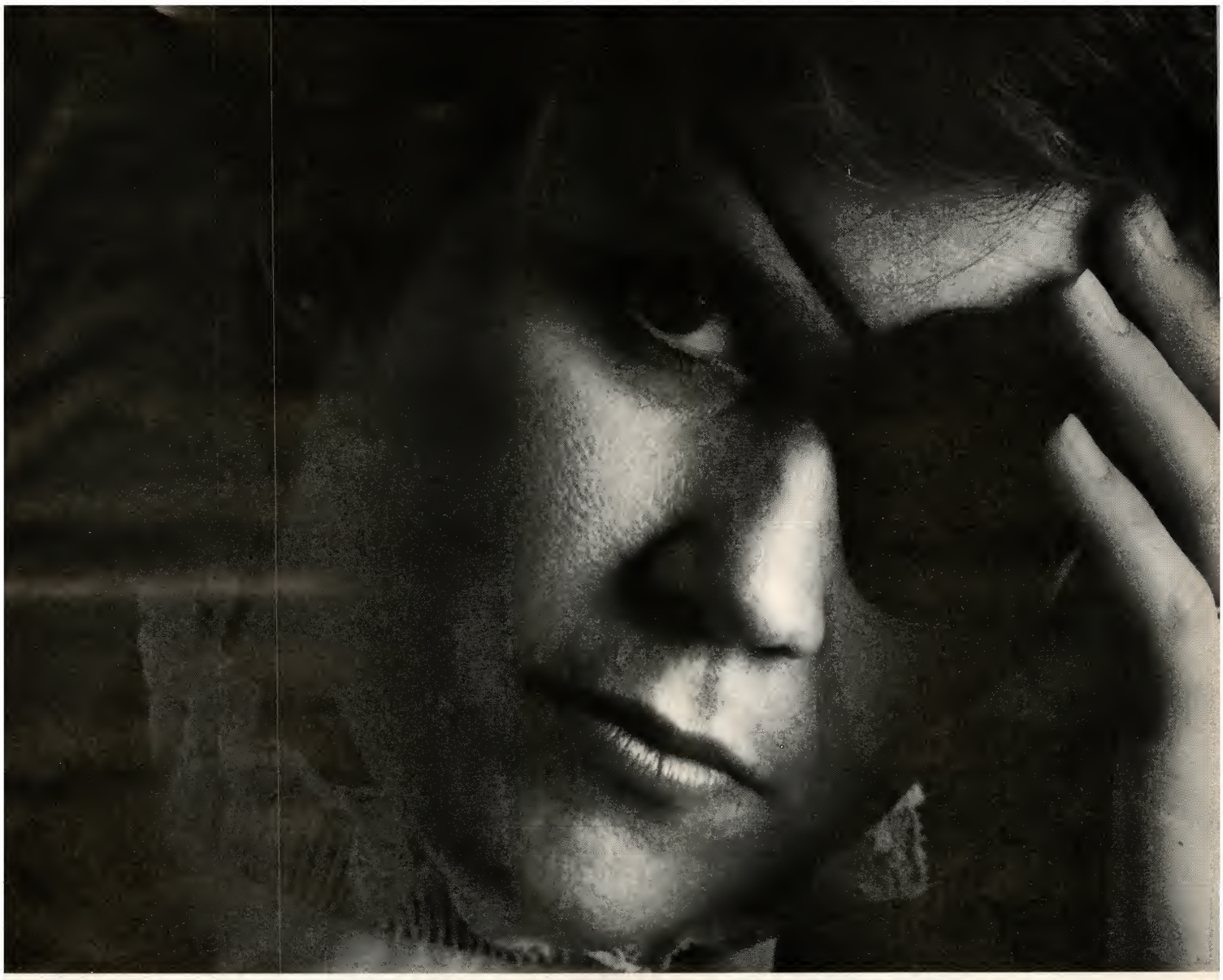
Three verification options are available as the program writes files to their new locations. The fastest version involves no verification and is perfectly satisfactory in most cases. In the second version, the program performs a cyclic redundancy check (CRC) on the data; this is equivalent to the DOS VERIFY command. In the third version, the highest level of verification, the program actually compares the newly written data with the data copied into memory from the file's old location; this option is rather slow.

Disk-optimization results are difficult to measure because the improvement in disk performance depends on the initial extent of file fragmentation. As an example, Fast Trax was used on a diskette containing a 70,000-byte text file. Before optimization, the file was stored in four extents on the disk (as determined by a disk-mapping program) and 10.9 seconds were required to read the file into a word processor. After optimization, the file was read in 9.2 seconds, a 16-percent improvement.

Although the speed benefits of disk optimization are not dramatic, they are real. Whether they are worth the cost of this program depends on the user's applications and need to squeeze out every last millisecond.

For maximum benefit, disk optimization should be performed once a week. Fast Trax's license agreement permits use of the program on an unlimited number of computers so long as it is used on only one machine at a time. Thus, sharing a copy of Fast Trax with others is legitimate, so long as license conditions are followed.

—PETER G. AITKEN



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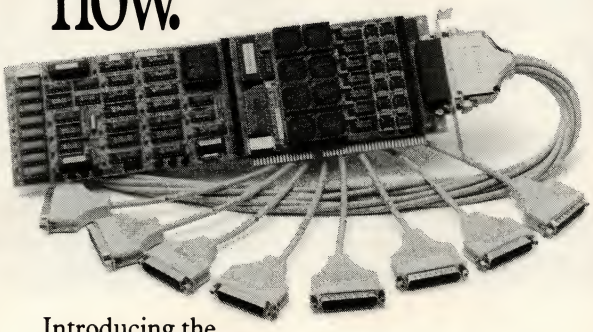
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Regional Copyright Law

Software developers' rights could vary dramatically from region to region because of differing court decisions on software copyright infringement cases.

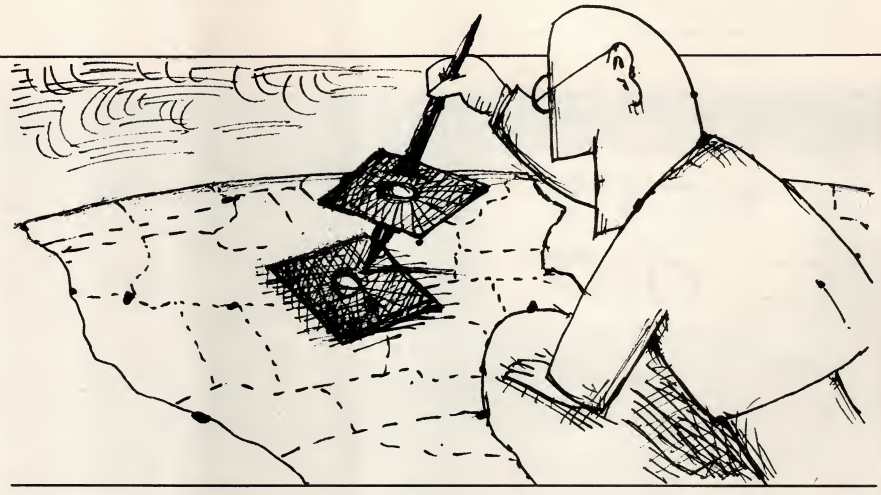


ILLUSTRATION • MACIEK ALBRECHT

Lotus Development Corporation has decided to fight back against software manufacturers who advertise their products as being similar to Lotus 1-2-3. The company is seeking court orders to recover damages and to prevent these manufacturers from publishing or advertising their products any further. Although pleas for a return to the good old days—when people who designed, built, and programmed computers were coadventurers sharing knowledge, inspiration, and sympathy—are unrealistic, there is justifiable concern that competition and innovation might decrease if software authors are given a monopoly on their work at too fundamental a level.

Surprisingly little attention has been focused on the possible short-term, direct impact on users. For example, Lotus' suit seeks a court order impounding and destroying all producers' goods that infringe any of Lotus' copyrights. It is not clear whether Lotus intends to draw the line at goods not already sold to customers or whether the law could compel Lotus to draw that line. The logic of Lotus' position also could reach beyond commercial producers of work-alikes to restrict users of original programs from customizing software for their own use.

To understand where we are and how we got here, it is necessary to review some previous cases. But take heed: do not look for consistent theory or uniform results—it is too early in the evolution of legal analysis. Remember that several levels of courts exist in both the federal and state systems. Each level within each system is subordinate to higher levels within its own system, but is not controlled by decisions (even of higher tribunals) in other systems (except for the United States Supreme Court, which has the final say).

For example, the lowliest state trial court magistrate is not bound by the decision of the highest court of another state, and the court of appeals for one federal circuit has no control over the lower courts in other circuits. Except for courts in direct line of authority, judicial opinions are of persuasive value only. In the area of computer-software copyrights, courts have fully exercised independent thought.

The burning copyright issue of 1879 was whether a copyright on a book explaining a new accounting system, which also contained diagrams showing how charts of account should be set up, precluded others from producing books that used the same system. The U.S. Supreme Court held that it did not, explaining

> where the art it teaches cannot be used without employing the methods and diagrams used to illustrate the book, or such as are similar to them, such methods and diagrams are to be considered as necessary incidents to the art, and given therewith to the public; not given for the purpose of publication in other works explanatory of the art, but for the purpose of practical application . . . Of course, these observations are not intended to apply to ornamental designs or pictorial illustrations addressed to the taste.

Necessary incidents to the use of a practical system are not protected; designs addressed to the taste are. The question to answer is: are user interfaces *incidents to the use* of a system or *designs addressed to the taste?*

A federal district court in Texas was faced with the question in 1978. Synercom Technology had produced a program to perform structural analysis. An easy-to-use field structure had value; in those days, the user entered data onto a punch card containing fields—just like a database program—and a number in the wrong field meant a wrong answer. University Computing also produced a program to perform structural analysis. It did not pilfer Synercom's code (although it did help itself to portions of Synercom's manual, which was held to be infringement); it merely wrote a preprocessor that would accept input in the form used by Synercom's program and translate it into a form compatible with its own, independently created program. University Computing simply wanted (as a matter of economic self-interest, to be sure) users of the market leader's program to feel at home. Synercom sued.

The court held that Synercom's copyright had not been infringed because ideas expressed by the order of input data could not be separated from the expression itself. The court also held that "formats are not copyrightable," comparing the situation to pro-

tecting the H-pattern automotive gear shift—once a car manufacturer had chosen the H-pattern, it could not prevent others from using the same pattern because its use was required for compatibility. It could monopolize a descriptive manual, sales brochure, or photograph, because forcing others to produce their own literature would not prevent them from entering the stick-shift market. For 10 years, this decision was the last word on protecting computer program interfaces.

LOOK AND FEEL

The phrase *look and feel* entered the computer law lexicon through Whelan v. Jaslow Dental Labs. The case cited an article in *InfoWorld* that said, "The 'look and feel' of a computer software product often involves much more creativity and often is of greater commercial value than the program code which implements the product."

Jaslow had hired Whelan to produce a custom program in EDL and agreed that Whelan would own the copyright. Whelan spent considerable time learning Jaslow's business and deciding how to structure the program. Jaslow was pleased with the results—so pleased, in fact, that it produced and marketed its own PC version.

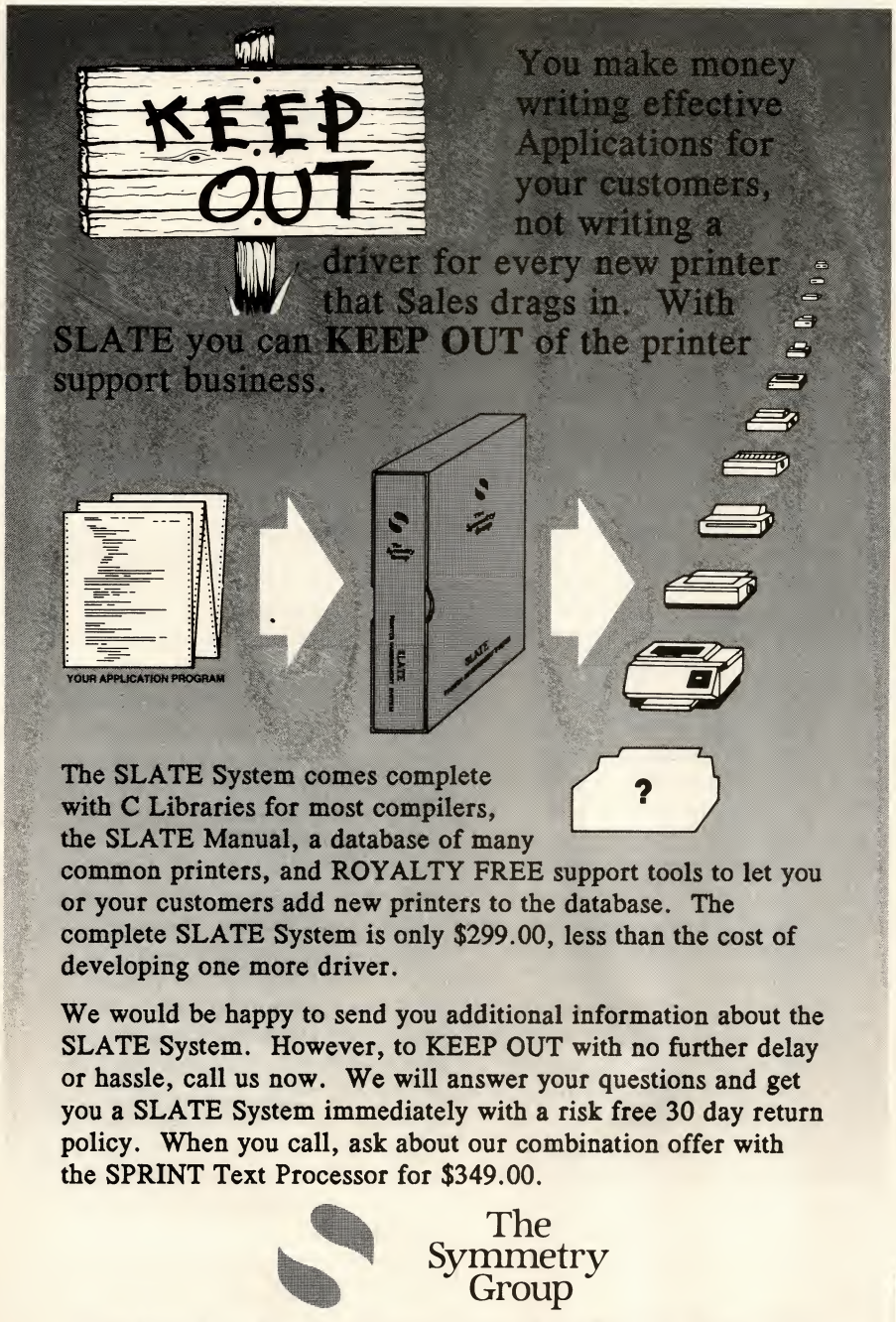
Although Jaslow's program was written in a different language for a different machine and Whelan never claimed that Jaslow had copied his code, the court held that Jaslow had infringed the program's overall "structure, sequence, and organization." The court also held that file structures can be copyrighted if they are "sufficiently innovative that the arrangement of information is itself informative," and that similar screen displays could be evidence of a similar underlying program. The U.S. Court of Appeals for the Third Circuit upheld the decision.

The Whelan case was not a battle of industry giants, but the decision sent vibrations from San Francisco in the Broderbund case to Cambridge in the Lotus cases. Does the user interface differ from the program structure as evidenced by its screen displays? If not, Synercom and Whelan are at odds. Who is in the right?

In Broderbund Software Inc. v. Unison World, Inc., Unison was negotiating with Broderbund for the rights to convert the Apple version of Print Shop for use on IBM PCs. During the negotiations, Unison had access to the Print Shop distribution disk (but not, the court found, to the source or object code), and instructed its programmers to recreate the Apple version for the PC. When negotiations broke down, the programmers were instructed to cease trying to copy Print Shop and to begin producing an "enhanced version." The programmers were not told to redo already completed portions.

Broderbund sued for copyright infringement. Unison took the Synercom/Baker tactic by arguing that no other conceivable way existed to structure a menu-driven computer program that allows users to print greeting cards, signs, banners, and posters. However, another such program, produced by Weekly Reader Family Software, seriously undercut the argument. Finding that the menu screens in Print Shop contained artwork, layout, and sequence having a creative, aesthetically pleasing style, the court held that Print Shop contained copyrightable elements and that Unison had infringed them.

Plains Cotton Cooperative Association of Lubbock, Texas, had developed a software package to help its members



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obtain information about and execute sales in the cotton market using terminals linked to its mainframe. Several former employees (who had helped to write the Plains Co-op program) went to work for Goodpasture Computer Services to develop a competing program for the PC market.

Experts testified that market factors play a significant role in determining sequence and organization; the former Plains employees testified that they did not rely on material belonging to Plains—and that they could, in fact, write a microcomputer program from scratch faster than they could translate one from a mainframe program. They added that Plains Co-op had not proved actual copying. Who wins?

In a ruling on a preliminary injunction, the Court of Appeals for the Fifth Circuit (which is not bound by the parallel court in the Third Circuit) declined to follow the Whelan analysis, partially because the record had not yet been fully developed; instead, it noted that when similarities are dictated by "externalities," then similar structure, sequence, and organization may not be evidence of infringement.

Thus, the precedents are equally divided for Lotus' two "structure and organization" cases that have been filed in federal court in Massachusetts. Each alleges copyright infringement and unfair competition from "deliberate . . . albeit inferior" copies of 1-2-3.

WHERE DO WE GO FROM HERE?

These cases are not superficially coherent; doubt still exists about what software authors can copy in pursuing compatibility. The answer may turn on whether what is copied is "artistic," just as the Supreme Court decided in 1879. That still leaves an apparent divergence in opinion about what is artistic.

Does it matter to those of us who do not write commercial software? It might, because uncertainty also exists about the law's impact on the innocent purchaser of an infringing product and on the rights of a purchaser to modify a lawful product to suit his own needs.

For example, suppose the producer of a work-alike loses a copyright infringement case to the producer of the original. Can the producer take back all the copies that have been sold? Lotus, in its suits, asks that all infringing copies be impounded and destroyed. No cases have been reported in which a court authorized the impoundment of copies already in consumers' hands—a court can issue orders only to the parties before it, and generally the only parties before the court in an infringement action are the plaintiff and the alleged infringer. However, in theory, a plaintiff could obtain from the defendant a list of its customers and pursue them.

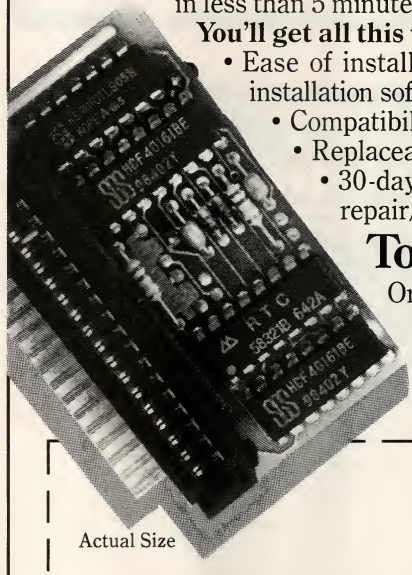
When Apple settled its infringement case with Franklin Computer, it allowed Franklin time to produce a noninfringing DOS and did not pursue prior purchasers of Franklin's computer (see "Memories are Made of This," Legal Brief, Max Stul Oppenheimer, June 1984, p. 34). However, in the pending case of Franklin Computer v. Language Arts (in which Franklin is suing the producer of a portion of the noninfringing DOS it used to settle the Apple suit), Franklin demanded a recall of ROMs from dealers. The issue did not have to be decided, however, because Language Arts (which contends that the allegedly infringing code is trivial) rewrote the code and voluntarily substituted ROMs.

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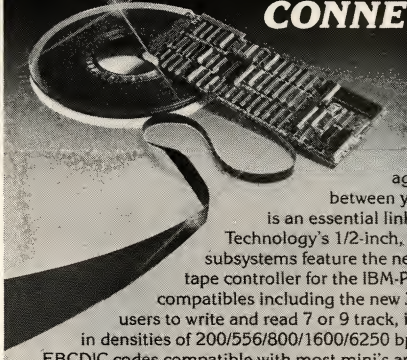
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Although the practicalities and public relations aspects of pursuing end users make the prospect seem remote, the Copyright Act does authorize, without limitation, the impounding and destruction of infringing copies. Users could be at higher risk if they have signed contracts containing an indemnification clause, common in some industries, giving the vendor the right, if threatened with an infringement suit, to repossess the allegedly infringing article. Those users face a dual threat: in an effort to settle with the plaintiff, a nervous defendant might exercise his contractual right to recall; or, a successful plaintiff might ask the court to order the defendant to exercise that contractual right. The reasons a user is unlikely to be pursued are the cost and adverse publicity; if the plaintiff can shift these burdens to the defendant, they are less of a barrier.

Although cases so far have involved the commercial sale of a program, copyright infringement does not turn on sale. Modifying a program for internal use could, in the proper circumstances, constitute infringement. This is of concern to software publishers because most license agreements attempt to restrict the right to modify.

The right to do so by shrink-wrap license is highly questionable in light of the recent federal district court decision in Vault v. Quaid (in which *PC Tech Journal* submitted an amicus curiae brief) invalidating Vault's shrink-wrapped license agreement. Software publishers may attempt to use copyright theories to accomplish the same result. The copyright statute allows a computer program to be adapted "as an essential step in the utilization of the computer program with a machine," but it is unclear how far that interpretation can be taken.

Will the Lotus cases finally resolve the copyright infringement issue? No, they will only add the voice of one more federal district court (or, if an appeal follows, one more federal circuit court). The Lotus cases could begin a process in which the country divides, case by case, circuit by circuit, into areas where the rights of software authors vary dramatically. Only the Supreme Court (which declined to review the Whelan decision) or federal legislation can resolve the issue.

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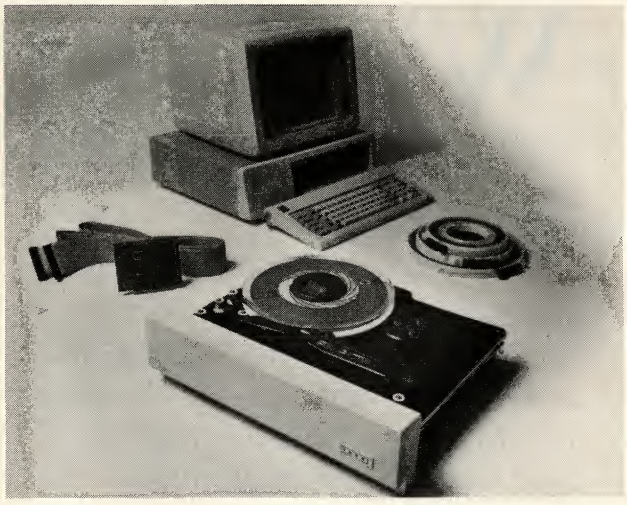
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CIRCLE NO. 258 ON READER SERVICE CARD

RS#	PRODUCT	ADVERTISER	PAGE
	IBM AND COMPATIBLE PC'S		
116	ALR Access 386	Advanced Logic Research	Cover 3
*	Compaq Computer Products	Compaq	153–155
182	386/Family	Televideo Systems Inc.	44–45
212	Intelligent Workstation	Telex Computer Products	173
	MULTIFUNCTION/MEMORY CARDS		
*	Rampage 2, Advantage 2	Ast Research	56–57
216	In Board	Intel Corp.	12, 13
180	d' Clock II	Micro Sync Inc.	221
148	FastCache-286, 287 Turbo Plus	Microway	161
159	Ramquest	Orchid Technology	112
	GRAPHICS CARDS		
206	EGA Wonder	ATI Technologies	82
161	PG 1281	Matrox	86
204	Vega Deluxe	Video 7	6–7
	MASS STORAGE HARDWARE		
111	9-Track Tape System	Catamount Corp.	227
123	9-Track Tape	Digi Data	215
124	9-Track Tape	Flagstaff Engineering	207
149	9-Track Tape System	Ibex Computer Systems	224
122	IDEATape	IDEAssociates	100
108	LEO	Innovative Data Technology	222
250	9-Track Tape System	M4 Data	227
185	Nine Track Micro-Mainframe Connection	Overland Data, Inc.	164
219	Data Manager	Seagate Technology	132–133
164	Back Up Systems	3M	28–29
	PRINTERS-PLOTTERS		
129	Print Master	Bay Technical Associates	66
194	J Laser Plus	Tall Tree Systems	33
	INPUT HARDWARE/SOFTWARE		
118	The Transterm 5 Terminal	Computerwise, Inc.	224
	DATA ACQUISITION		
209	Catalogue	Interactive Microware	218
	MONITORS		
138	MJ503 Monitor	Teknica	174
	MICRO-MINI MAINFRAME COMMUNICATIONS		
239	KB 3270	Keytronics Int.	179
189	The Block	Software Security	99
	LOCAL AREA NETWORKS		
165	Extra	Attachmate Corp.	199
172	Easy Queue	Giltronix	128
	OTHER COMMUNICATION HARDWARE		
110	Digiboard COM/XI	Digiboard Inc.	218
199	Galacticomm Breakthrough	Galacticomm, Inc.	21
177	Stargate OC8000	Stargate Technologies	193
	OTHER COMMUNICATION SOFTWARE		
167	Crosstalk	Crosstalk Communications	Back Cover
228	Carbon Copy	Meridian Technology	81
196	LAN Link	Software Link	205
	LANGUAGES		
136	Prolog Compiler	Arity Corp.	146
254	BASIC, Prolog, Pascal	Borland Int.	Front Cover
131	C Products	Ecosoft Inc.	175
*	The Weiner Shell	Gryphon Microproducts	224
160	Lattice Services	Lattice, Inc.	131
263	Personal Rexx	Mansfield Software	162
*	Language Newsletter	Microsoft Corp.	23
*	Microsoft C	Microsoft Corp.	17–21
150	QuickBASIC	Microsoft Corp.	105
205	Cross Development Systems	Oregon Software	85
141	Realia COBOL	Realia Inc.	123
130	Brief	Solution Systems	14
	PROGRAMMER'S TOOLS		
203	PC Probe	Atron	8
249	Mini Probe	Atron	16
104	Power Tools Plus	Blaise Computing	37
102	C Tools Plus	Blaise Computing	25
*	De Smet C Version 3.0	C Ware	218
232	PC Tools	Central Point Software	22
*	Vitamin	Creative Programming	26
145	Quick Pak/Qbase	Crescent Software	189
261	PC/VI	Custom Software Systems	150
119	R-Tree/C-Tree	Faircom	24
109	PC/Forms Screen Mgmt.	Golden Software	119
*	The Weiner Shell	Gryphon Microproducts	224
113	Flowchart	Haventree Software	134
148	C-Tree Query	Kurtzberg Computer System	126
125	Epsilon	Lugaru Software	162
163	Help/Control	MDS, Inc.	152
259	386 Compiler	Metaware	227
262	VS COBOL Workbench	Micro Focus Ltd.	54
120	XRAY	Micro Tech Research	117
191	ScreenIO	Norcom	122
222	Scroll & Recall, Opt-Tech/Sort	Opt-Tech Data Processing	4
103	Mace-Utilities	Paul Mace	172
*	Programmer's Tools	PC Brand	88–91
215	Periscope	Periscope Company	5
183	The Norton Editor	Peter Norton Computing	207
192	The Norton Editor	Peter Norton Utilities	40–41
201	Btrieve	Softcraft	2
142	Demo Program	Software Garden	149
152	Keep Out Slate System	Symmetry Group	220
115	Windows for Data	Vermont Creative	27
132	UI Programmer	Wallsoft Systems Inc.	160
154	XO-SHELL	Wyte Corp.	190
	SOFTWARE UTILITIES		
191	ScreenIO	Norcom	122
103	Mace Utilities	Paul Mace Software	172
157	Software Sentinel	Rainbow Technologies, Inc.	163
176	Speedstar	Storage Dimensions	222
	EXPERT SYSTEMS/AI SOFTWARE		
*	PC Scheme	Texas Instruments	200
	GRAPHICS SOFTWARE		
107	Graph C 4.0 and VTEK 4.0	Scientific Endeavors Corp.	227
	DATA BASE MANAGEMENT SOFTWARE		
153	Magic PC	Aker Corp.	51
*	Paradox 2	Ansa Software	136–137
211	MDBS III	Micro Data Base Systems	94
224	Clipper	Nantucket Corp.	171
*	DB VISTA	Raima Corp.	11
156	Unify	Unify Corp.	118
236	ZIM	Zanthe	208–210
	OPERATING SYSTEMS		
253	OS/286 and OS/386	AI Architects	103
184	VM/386	Intelligent Graphics Corp.	144
258	AMX Multitasking Executive	Kadak Products Ltd.	224
140	Merge 386	Locus Computing Corp.	68
174	MKS Tool Kit	Mortice Kern Systems Inc.	159
181	QNX	Quantum Software Systems	192
137	DESQview	Quarterdeck Office Systems	35
169	Multilink Advanced	Software Link	182
	PUBLICATIONS		
101	IBM Personal System/2	John Wiley & Sons Inc.	87
	OTHER SERVICES		
238	Smartmodern 9600 and 2400	Hayes Microcomputer Products	166, 167
210	PC-AT Board Level	I-BUS Systems	151
155	Documentation	Xanthus	198
	MAIL ORDER		
147	Mail Order	Byte Connection, Inc.	232
117	Mail Order	CDA World of Computers	230
235	Mail Order	Computer Classifieds, Inc.	231
134	Mail Order	ITS	229
247	Mail Order	Precision Data Products	230
175	Mail Order	Programmer's Connection	71–73
173	Utilities, Editors,	Programmer's Paradise	233
162	Mail Order	Programmer's Shop	42, 127
240	Mail Order	Scantel Systems Ltd.	230
127	Mail Order	Scottsdale Systems	232
*	UNLock	TranSec Systems Inc.	232

INDEX TO ADVERTISERS

READER SERVICE NUMBER	ADVERTISER	PAGE
116	Advanced Logic Research	Cover 3
253	AI Architects	103
153	Aker Corporation	51
*	Ansa Software	136, 137
136	Arity Corporation	146
*	AST Research	56, 57
206	ATI Technologies	82
203	Atron	8
249	Atron	16
165	Attachmate Corporation	199
129	Bay Technical Associates	66
102	Blaise Computing	25
104	Blaise Computing	37
*	Borland International	Cover 2
254	Borland International	1
147	Byte Connection, Inc.	232
*	C Ware	218
111	Catamount Corporation	227
117	CDA World of Computers	230
232	Central Point Software	22
*	Compaq	153–155
235	Computer Classifieds, Inc.	231
118	Computerwise, Inc.	224
*	Creative Programming Cons	26
145	Crescent Software	189
167	Crosstalk Communications	Back Cover
261	Custom Software Systems	150
123	Digi Data	215
110	Digiboard Inc.	218
131	Ecosoft Inc.	175
119	Faircom	24
124	Flagstaff Engineering	207
199	Galacticomm, Inc.	21
172	Giltronix	128
109	Golden Software	119
*	Gryphon Microproducts Inc.	224
113	Haventree Software	134
238	Hayes Microcomputer	166, 167
210	I-BUS Systems	151
149	Ibex Computer Systems	224
122	IDE Associates	100
108	Innovative Data Technology	222
216	Intel Corporation	12, 13
184	Intelligent Graphics Corp.	144
171	Intelligent Optics Corp.	39
209	Interactive Microware	218
134	ITS	229
101	John Wiley & Sons Inc.	87
258	Kadak Products LTD.	224
239	Keytronics International	179
148	Kurtzberg Computer System	126
160	Lattice, Inc.	131
140	Locus Computing Corp.	68
125	Lugaru Software	162
250	M4 Data	227
263	Mansfield Software	162
161	Matrox	86
163	MDS, Inc.	152
228	Meridian Technology	81
259	Metaware	227
211	Micro Data Base Systems	94
262	Micro Focus Ltd	54
180	Micro Sync Inc.	221
120	Micro Tech Research	117
*	Microsoft Corporation	23
*	Microsoft Corporation	17–21
150	Microsoft Corporation	105
148	Microway	161
174	Mortice Kern Systems Inc.	159
224	Nantucket Corporation	171
191	Norcom	122
222	Opt Tech Data Processing	4
159	Orchid Technology	112
205	Oregon Software	85
185	Overland Data, Inc.	164
103	Paul Mace Software	172
*	PC Brand	88–89
*	PC Brand	90–91
215	Periscope Company	5
231	PerStor	106
183	Peter Norton Computing	207
192	Peter Norton Utilities	40–41
247	Precision Data Products	230
175	Programmer's Connection	71–73
173	Programmer's Paradise	233
162	Programmer's Shop	42, 127
181	Quantum Software Systems	192
137	Quarterdeck Office System	35
*	Raima Corp.	11
157	Rainbow Technologies, Inc.	163
141	Realia Inc.	123
240	Scantel Systems Ltd.	230
107	Scientific Endeavors Corp.	227
127	Scottsdale Systems	232
219	Seagate Technology	132
219	Seagate Technology	133
201	Softcraft	2
142	Software Garden	149
196	Software Link	205
169	Software Link	182
189	Software Security	99
130	Solution Systems	14
177	Stargate Technologies	193
176	Storage Dimensions	222
152	Symmetry Group	220
194	Tall Tree Systems	33
138	Teknica	174
182	Televideo Systems Inc.	44–45
212	Telex Computer Products	173
*	Texas Instruments	200
164	3 M	28, 29
*	TranSec Systems Inc.	232
156	Unify Corporation	118
115	Vermont Creative	27
204	Video 7	6–7
132	Wallsoft Systems Inc.	160
154	Wyte Corp.	190
155	Xanthus	198
236	Zanthe	208–210

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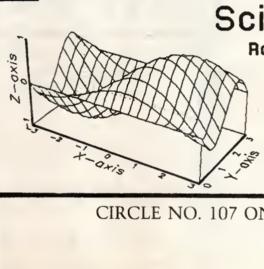
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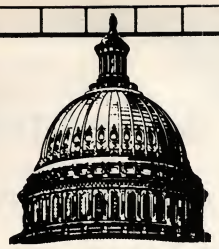
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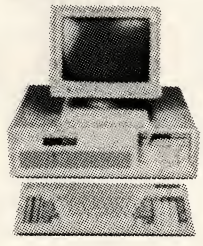
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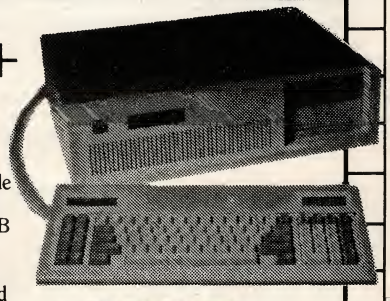
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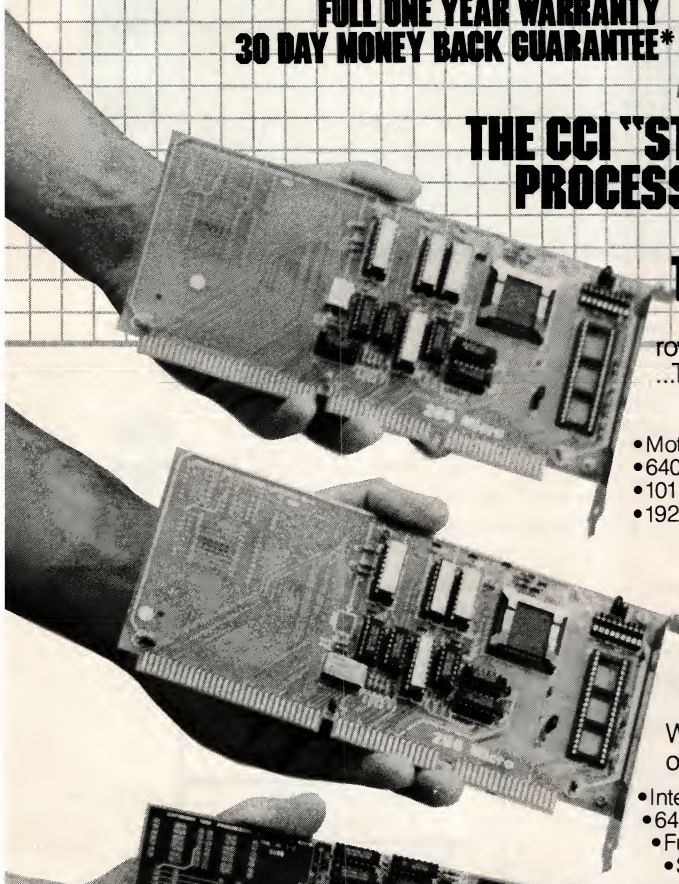
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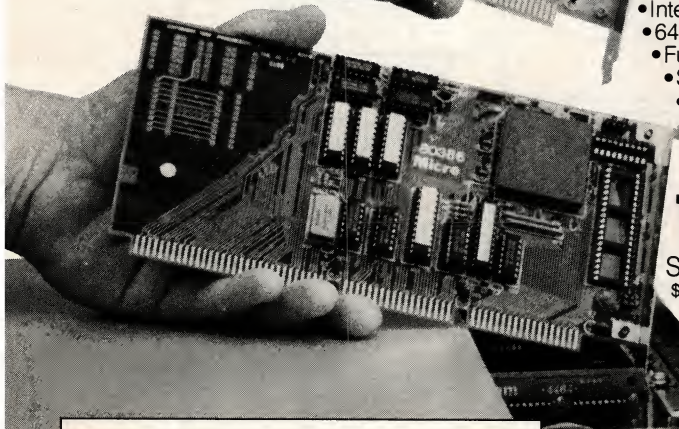
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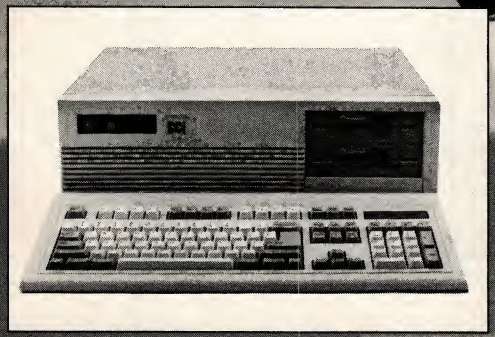


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PRODUCT CATEGORIES

HARDWARE 235-236

ACCESSORY CARDS 235
COOLING DEVICES .....
COMMUNICATIONS .....
COMPATIBLES 236
GENERAL 236
MASS STORAGE .....
PERIPHERALS 236
SECURITY DEVICES .....
USED EQUIPMENT .....

SOFTWARE 236-243

ARTIFICIAL INTELLIGENCE .....
BUSINESS 236, 243
COMMUNICATIONS 236
DATA BASE MANAGEMENT .....
EDUCATIONAL .....
ENGINEERING 237
EXPERT SYSTEMS .....
FINANCIAL .....
GENERAL 237
GRAPHICS 237
LANGUAGES 237
MULTI/USER SYSTEMS .....
NETWORKING 237

SOFTWARE *continued*

OPERATING SYSTEMS 238
PROGRAMMERS TOOLS 238-239
PUBLIC DOMAIN 240
SCIENTIFIC 240
SECURITY DEVICES 240
STATISTICS 240
TERMINAL EMULATION 240
UTILITIES 241-243
WORD PROCESSING .....

MISCELLANEOUS 243

ACCESSORIES .....
BAR CODING 243
BUSINESS OPPORTUNITIES .....
PUBLICATIONS 243
SUPPLIES .....

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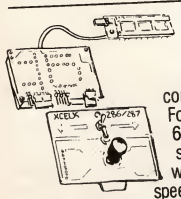
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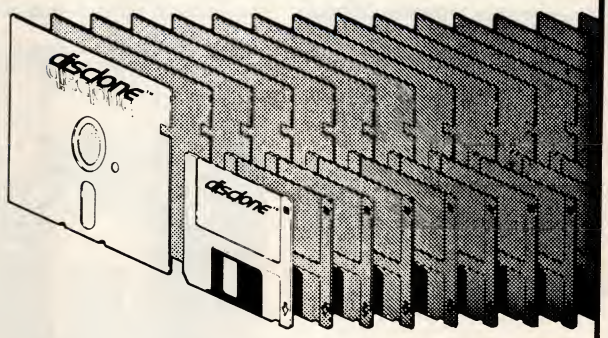
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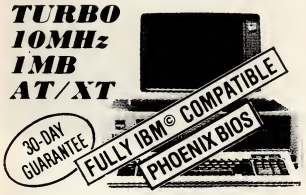
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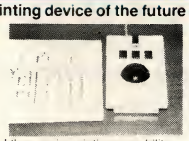
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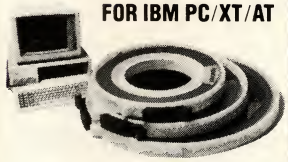
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continued on page 243

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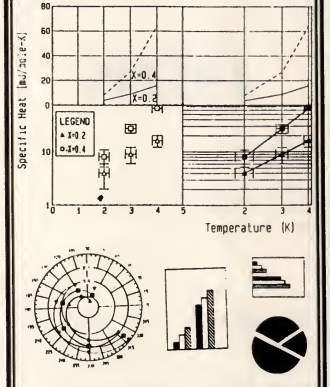
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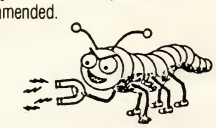
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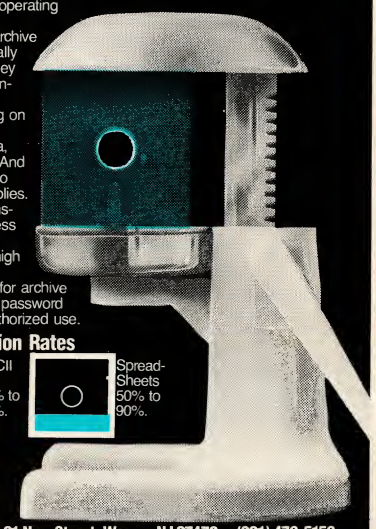
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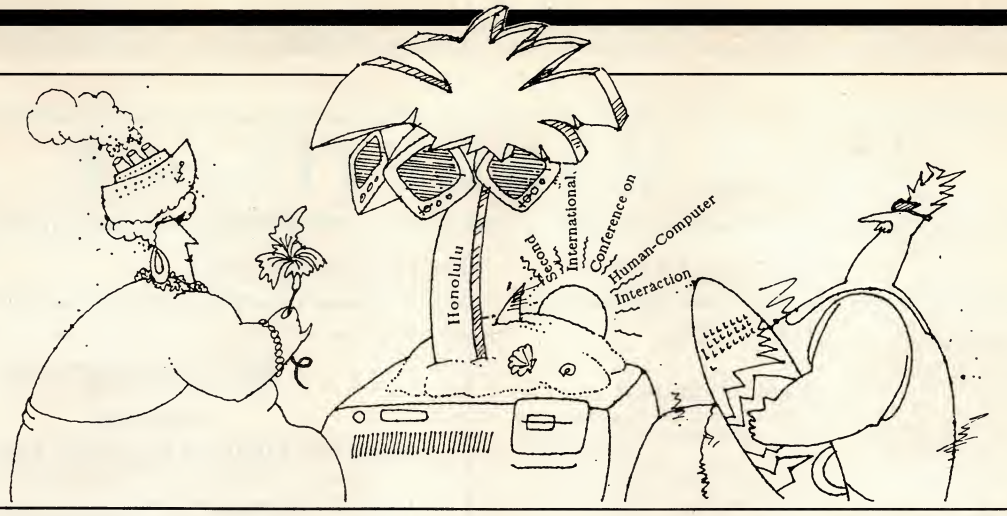


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AUGUST

August 10–14
Computer Art and Design Conference
Boston, MA (National Computer Graphics Association) *Contact:* NCGA, 2722 Merrilee Drive, Suite 200, Fairfax, VA 22031; 800/225-6242; 703/698-9600

August 10–15
Human-Computer Interaction
Honolulu, HI (International Commision on Human Aspects in Computing) *Contact:* Gavriel Salvendy, School of Industrial Engineering, Purdue University, West Layfayette, IN 47907; 317/494-5426

August 17–20
CAD/CAM '87
Boston, MA (National Computer Graphics Association) *Contact:* NCGA, 2722 Merrilee Drive, Suite 200, Fairfax, VA 22031; 800/225-6242; 703/698-9600

August 19–21
COMDEX/Australia
Sydney, Australia (Interface Group) *Contact:* The Interface Group, Inc., 300 First Avenue, Needham, MA 02194; 617/449-6600

August 20
Developing AT Graphics
New York, NY (Graphic Software Systems) *Contact:* Dan Fineberg, GSS, Inc., 9590 S.W. Gemini Drive, Beaverton, OR 97005; 503/641-2000

August 23–28
IJCAI '87
Milan, Italy (International Joint Conferences on AI) *Contact:* John McDermott, CS Dept., Carnegie-Mellon University, Pittsburgh, PA 15213; 415/328-3123

SEPTEMBER

September 1–3
PC EXPO
New York, NY (PC EXPO) *Contact:* Jim Mion, PC EXPO, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632; 800/922-0324; in New Jersey, 201/569-8542

September 21–23
Conference on Software Maintenance
Austin, TX (NBS, DPMA, and IEEE-CS) *Contact:* Roger Martin, National Bureau of Standards, Bldg. 225, Rm. B266, Gaithersburg, MD 20899; 301/921-3545

September 23–25
***PC Tech Journal* Systems Forum**
San Diego, CA (*PC Tech Journal*) *Contact:* Marti Cunha, *PC Tech Journal*, Suite 800, Little Patuxent Parkway, Columbia, MD 21044; 301/740-8300

September 28–29
Software Engineering and CASE Technology
Seattle, WA (Digital Consulting, Inc.) *Contact:* Seminar Services Dept., 6 Windsor St., Andover, MA 01810; 617/470-3870

September 28–October 1
Conference on Electronic/Desktop Publishing
San Francisco, CA (National Computer Graphics Association) *Contact:* NCGA, 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031; 800/225-6242; 703/698-9600

September 29–October 2
INFO '87 and INFO/Software
New York, NY (INFO 87) *Contact:* Frank Fazio, Show Manager, INFO '87, 999 Summer Street, Stamford, CT 06905; 203/964-0000

OCTOBER

October 4–8
OOPSLA '87
Kissimmee, FL (ACM SIGPLAN) *Contact:* Object Oriented Programming: Systems, Languages, and Applications Conference; ACM, 11 W. 42nd Street, New York, NY 10036; 212/869-7440

October 5–7
National Connectivity Symposium
Chicago, IL (Digital Consulting, Inc.) *Contact:* Seminar Services Dept., 6 Windsor St., Andover, MA 01810; 617/470-3870

October 5–8
ASPLOS-II
Palo Alto, CA (ACM SIGPLAN) *Contact:* Architectural Support for Programming Languages and Operating Systems Conference, ACM, 11 W. 42nd Street, New York, NY 10036; 212/869-7440

October 13–15
PC EXPO/Chicago
Chicago, IL (PC EXPO) *Contact:* Jim Mion, PC EXPO, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632; 800/922-0324; in New Jersey, 201/569-8542

October 15–17
Northeast Computer Faire
Boston, MA (The Interface Group, Inc.) *Contact:* The Interface Group, Inc., 300 First Avenue, Needham, MA 02194; 617/449-6600

October 19–23
Expert Systems in Government
Washington, DC (Mitre Corporation and IEEE-CS) *Contact:* IEEE-CS, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903; 202/371-0101

October 20–22
NetWorld '87
Dallas, TX (PC EXPO) *Contact:* Annie Zdinak, PC EXPO, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632; 800/526-3247; in New Jersey, 201/569-6409

October 27–29
UNIX EXPO
New York, NY (National Expositions Company) *Contact:* National Expositions Company, Inc., 49 W. 38th Street, Suite 12A, New York, NY 10018; 212/391-9111

October 28–30
AI/East '87
Atlantic City, NJ (Tower Conference Management) *Contact:* Tower Conference Management, 331 W. Wesley Street, Wheaton, IL 60187; 312/668-8100

NOVEMBER

November 3–5
COMDEX/Fall
Las Vegas, NV (The Interface Group, Inc.) *Contact:* The Interface Group, Inc., 300 First Avenue, Needham, MA 02194; 617/449-6600

November 9–11
Symposium on Operating System Principles
Austin, TX (ACM SIGOPS) *Contact:* Les Belady, Microelectronics Computer Consortium (MCC), 9430 Research Blvd., Echelon Building 1, Suite 200, Austin, TX 78759; 512/834-3330

November 9–11
Optical Storage for Small Systems
Los Angeles, CA (Rothchild Consultants) *Contact:* Rothchild Consultants, 256 Laguna Honda Blvd., San Francisco, CA 94116-1496; 415/681-3700

November 9–12
Mapping and Geographic Information Systems '87
San Diego, CA (National Computer Graphics Association) *Contact:* NCGA, 2722 Merrilee Drive, Suite 200, Fairfax, VA 22031; 800/225-6242; in Virginia, 703/698-9600

November 9–12
ICCAD-87
Santa Clara, CA (IEEE-CS) *Contact:* International Conference on Computer-aided Design, IEEE-CS, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903; 202/371-0101

DECEMBER

December 6–9
International Conference on Information Systems
Pittsburgh, PA (Society for Information Management) *Contact:* William D. King, Graduate School of Business, University of Pittsburgh, Pittsburgh, PA 15260; 412/648-1587

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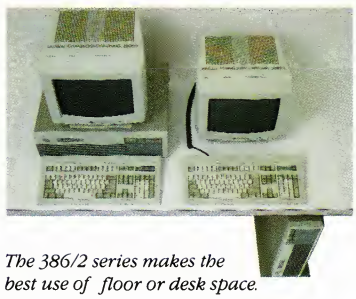
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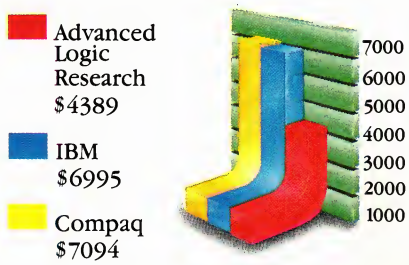
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